

The Philippine Agriculturist

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- A Study on the Germination of
Abaca Seeds** *L. G. Ferrer and R. B. Espino* 101
- Absorption of Complete Culture
Solutions by Abaca Roots
with Reference to Growth
of Branch Roots** *R. B. Espino and S. M. Cruz* 111
- Soil Moisture Requirements of
Young Abaca Plants** *P. Hernais and R. B. Espino* 121
- A Preliminary Study of the Salt
and Fertilizer Needs of the
Young Abaca Plant** *R. B. Espino and B. O. Viado* 127
- Foliar Transpiring Power of Dif-
ferent Varieties of Abaca
Grown at the College of
Agriculture** *Perpetuo Gavarra and R. B. Espino* 135
- Comparative Study of Fibers
Produced by Six Varieties
of Abaca when Grown in
Los Baños: I** *R. B. Espino and Felix Esguerra* 141
- Comparative Study of Fibers
Produced by Six Varieties
of Abaca when Grown in
Los Baños: II** *R. B. Espino and José Chico Reyes* 153
- Comparative Study of Forty-
Seven Varieties of Abaca
Grown under Los Baños
Conditions** *R. B. Espino and Teofilo Novero* 165

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A STUDY ON THE GERMINATION OF ABACA SEEDS¹

By L. G. FERRER and R. B. ESPINO

The propagation of abaca by seeds is possible (1), though very little is yet known about conditions influencing the germination of the seeds (2) (3). With the object of obtaining some data on the subject a series of experiments on the germination of abaca seeds was carried out at the College of Agriculture during the college year 1922-23.

Seeds of three varieties of abaca were used in the experiments. All of them came from bunches of ripe abaca fruit and were freed from the pulp by rubbing. Care was taken not to injure the seeds, nor to mix varieties. Depending upon the nature of the experiment, the seeds were secured or prepared as follows:

- (1) The seeds from one bunch of fruit were mixed together.
- (2) The seeds from the different hands of each bunch of fruit were separately prepared, or extracted.
- (3) The seeds from the different fingers on the different hands of each bunch of fruit were separately extracted.

Eight sets of experiments were made, some with a certain treatment for the seeds, others without. In all cases the seeds were ultimately sown in ordinary wooden germinating boxes, each containing a sufficient amount of sterilized garden soil kept constantly moist but never allowed to become saturated with water. The experiments were conducted in a place partly exposed to the sun, so that the drying conditions of the surroundings were never intense, nor was the place cold. The series of experiments made together with their respective results may be briefly stated as follows:

- (1) *To find whether the formation and development of seeds depends upon self-pollination or upon cross-pollination.*

Thirty inflorescences, or hearts of abaca varieties Libuton and Itom, were bagged before the first bract on each heart opened. The tests were made in the Abaca Nursery of the College and in the Maquiling Abaca Plantation.

Not a single fruit developed and after two months the inflorescences shriveled and dried up. The results plainly show that the abaca plant (varieties Libuton and Itom) is cross-pollinated and that the formation and development of fertile seeds depend upon it. The production of self-fertilized, or inbred seeds cannot be expected.

¹ Thesis presented for graduation from the College of Agriculture, No. 151; Experiment Station contribution, No. 123.

(2) *To find the comparative germination of seeds from different bunches of fruit of one variety and of seeds of different varieties.*

Without any previous treatment the seeds were sown in the germinating boxes. The summary of the results as well as part of the details of the experiment are given in Table I.

(3) *To find the comparative rate and percentage of germination of seeds from the different "fingers" on the different "hands" of a bunch of fruit.*

Here again the seeds from the different fingers were sown without any previous treatment. More of the details of the technique together with the summary of results may be found in Table II.

(4) *To find the effects of drying the seeds upon the rate and percentage of germination.*

The plan of the experiments together with the summary of the results may be seen in Table III.

(5) *To find the effects on germination of soaking the seeds in water of different temperatures.*

Because of lack of seeds this experiment was performed in three sets. Water with 30°C. and 40°C. was tried first; 60°C. and 70°C. together; and 50°C., 80°C., and 100°C. were run at the same time. The summary of results is given in Table IV.

(6) *To find the effect on germination of soaking the seeds in certain inorganic acids.*

A general scheme of the experiment together with the summary of the data is shown in Table V.

(7) *To find the influence upon germination of passing the seeds through the alimentary canal of man and of some animals.*

Pieces of fruit with seeds in them were fed (a) to chickens, (b) to a monkey and, (c) to man. All of the seeds fed to the chickens were digested, but those which left the alimentary system of man and of the monkey were in perfect condition. When sown many of them germinated. The results from this experiment are summarized in Table VI.

(8) *To find the effect of delayed planting upon the rate and percentage of germination of seeds.*

Seeds of one variety of abaca were gathered, dried in the shade, mixed thoroughly, and stored in a large bottle. At monthly intervals, from June 6, 1922, till February 6 of the following year, a planting of 200 seeds was made. The bulk of the results from the experiment is not here given, but a summary is presented in Table VII.

SUMMARY OF RESULTS

(1) The failure of abaca plant (varieties Libuton and Itom) to produce seeds when very young inflorescences were bagged is a clear indication that the plant is cross-pollinated. The arrangement and the order of development of the pistillate and staminate flowers on an inflorescence make cross-pollination the only possibility.

(2) The seeds of abaca of the three varieties planted under ordinary conditions required from 11 to 24 days before they began to germinate. The germination period spread over a period of from 18 to 52 days. From 20 to 89 per

cent germination was obtained. The seeds obtained from the different hands on each bunch of fruit had about the same degree of viability, but those obtained from different bunches of fruit of one variety had different germinating power, (see Table I).

(3) The seeds from the three different bunches of fruit from one plant had different percentages of germination. Seeds from all the hands on each bunch of fruit were viable. There was not any direct correlation between percentage of sprouting and the seeds obtained from the different hands on each bunch. In some cases hand 1 or 2 had seeds more viable than those obtained from the other hands. But contradictory results were also obtained.

The degree of viability of the seeds does not depend upon the position of the fingers on each hand (Table II).

(4) Drying the seeds in the sun for 24, 48 or 72 hours caused a loss of vitality. The seeds planted immediately after removal from the fruit pulp, as well as those dried in the shade for 24 hours before planting, showed a certain degree of viability. A higher percentage of germination was obtained from the former than from the latter (see Table III).

(5) The seeds which were soaked in water with a temperature of 40°C. at different durations required from about 21 to 38 days before germination took place; 35 to 38 days for seeds soaked in water for 15 and 20 minutes, respectively; 22 was the approximate average of days before germination (see Table IV).

Soaking in water with a temperature of 40°C. caused abaca seeds to germinate from 2 to 5 days earlier than when the seeds were soaked in water with a temperature of 30°C. However, the percentage of germination was about the same in both cases (Table IV).

The seeds that were soaked for 5 minutes, 10 minutes, or 15 minutes in water with a temperature of 70°C. all failed to germinate. About 21 per cent germination was obtained when the seeds were soaked for 5 minutes in water with a temperature of 60°C. When soaked in the same water for 10 minutes the percentage of germination decreased to 16 (Table IV).

All the seeds that were soaked for different periods in water with a temperature of 80°C. or 100°C. seemed to have lost their viability (Table IV).

Cases were observed in which seeds of abaca sown in a germinating box required more than 100 days before they sprouted. An extreme case of 155 days was recorded (Table IV).

(6) The rate and percentage of germination of seeds previously soaked in various inorganic acids at different concentrations and durations were not constant. In fact, the percentage of success was extremely low, and there was not any material saving of time before germination (Table V).

(7) All the seeds fed to chickens were digested. Those fed to man had the highest percentage of germination and in much the shortest time. Although the seeds that passed the stomach of the monkey were not digested yet the percentage of germination was relatively low (Table VI).

(8) There are indications that the seeds of abaca may lose vitality about three months after harvesting the seeds (Table VII). However, seeds buried in the ground may remain alive for 155 days (Table IV).

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College of Agriculture, Los Baños. 1921.
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TABLE I.—Summary of comparative germinating power of seeds obtained from different varieties of abaca.

Variety: Libuton.																												
Bunch I.					Bunch II.					Bunch III.					Bunch IV.					Bunch V.								
Hand number.					Hand number.					Hand number.					Hand number.					Hand number.								
1	2	3	4	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	7
July 22, 1922					July 22, 1922					August 16, 1922					August 16, 1922					August 19, 1922								
157 582 658 382 403 274 299 112 697 152 217 220 315 324 325 180 305 309 307 398 197 121 970 690 577 901 1000 459 638																												
24 21 23 21 21 22 22 22 21 22 14 16 14 14 14 16 17 12 16 11 11 13 18 19 18 19 19 17 17																												
47 43 66 32 50 41 49 57 43 45 48 51 56 60 57 57 54 74 54 59 60 75 67 65 57 55 55 66 66																												
99 310 360 236 284 209 259 83 430 89 65 63 144 128 111 87 62 71 104 115 68 70 247 213 206 317 315 180 225																												
63.1 53.3 54.7 61.8 70.5 76.3 86.6 74.1 61.7 58.6 29.9 28.6 45.7 39.5 34.2 48.3 20.3 23.0 33.8 28.9 34.5 57.9 25.5 30.9 35.7 35.1 31.5 39.2 35.2																												
Date of sowing.....																												
Seeds sown.....																												
Days before germination.....																												
Days germinating.....																												
Seeds germinated.....																												
Per cent germination.....																												
Variety: Taifongon.													Variety: Itom.															
Bunch I.					Bunch II.					Bunch I.																		
Hand number.					Hand number.					Hand number.																		
1	2	3	4	5	1	2	3	4	5	6	1	2	3	4	5	6	7	8										
July 24, 1922					July 24, 1922					July 25, 1922																		
137 386 194 485 378 15 560 819 460 360 328 2511 2904 1276 2067 1745 1992 908 1935																												
21 20 19 19 19 19 19 19 19 19 19 22 20 19 20 19 19 19 19 19																												
41 29 30 29 29 26 47 18 47 30 37 52 51 30 44 45 33 30 28																												
112 232 130 179 205 173 349 223 138 214 144 1690 1185 1080 809 1009 694 369 763																												
81.8 60.1 67.0 36.9 54.2 80.5 62.3 27.2 30.0 59.4 43.9 67.3 40.8 84.6 39.1 57.8 34.0 53.9 4																												

TABLE II.—Summary of results obtained from an extensive test on the comparative rate and percentage of germination of seeds of abaca (Variety Libuton) from the different fingers on the different hands.

	Bunch I.											Bunch II.							Bunch III.							
	Hands number.						Hands number.							Hands number.												
	1	2	3	4	5	6	1	2	3	4	5	6	7	1	2	3	4	5	6	7	8					
Finger No. 1	June 14, 1922						July 20, 1923							July 21, 1922												
Date of sowing.....	122	88	110	97	55	93	31	55	47	59	55	63	63	31	31	45	59	25	28	28	40					
Seeds sown.....	27	41	31	29	38	38	21	29	104	36	21	21	21	22	22	23	22	20	27	21	26					
Days before germination...	37	66	54	55	58	17	43	75	24	9	52	70	65	31	31	30	31	33	50	55	52					
Days germinating.....	100	44	75	55	20	32	15	12	3	2	9	18	18	15	19	16	28	18	14	16	23					
Seeds germinated.....	82.0	50.0	68.2	56.7	36.4	34.4	48.4	21.8	6.4	3.4	16.4	28.6	28.6	48.4	61.3	35.6	47.5	72.0	50.0	57.1	57.5					
Per cent germination.....																										
Finger No. 2	June 14, 1922						July 20, 1922							July 21, 1922												
Date of sowing.....	108	73	140	127	30	95	39	65	55	78	54	66	58	41	64	33	45	26	40	35	25					
Seeds sown.....	24	31	31	29	31	34	26	23	27	34	21	29	21	27	20	21	29	20	27	21	22					
Days before germination...	45	53	46	42	58	74	25	37	46	42	28	41	49	42	42	52	47	11	36	19	31					
Days germinating.....	95	55	90	83	19	36	10	11	13	1	9	14	16	17	46	20	13	12	18	17	10					
Seeds germinated.....	88.0	75.3	64.3	65.4	63.3	37.9	25.6	16.9	23.6	3.16	7.2	21.2	27.6	41.5	71.9	60.6	28.9	46.2	45.0	48.6	40.0					
Per cent germination.....																										
Finger No. 3	June 14, 1922						July 20, 1922							July 21, 1922												
Date of sowing.....	118	91	134	199	56	97	67	56	75	72	60	41	32		53	36	46	48	48	33	20					
Seeds sown.....	27	29	31	25	29	40	23	23	26	38	21	29	21		20	23	26	20	28	21	22					
Days before germination...	42	53	48	41	52	29	57	45	36	17	52	39	46		24	49	32	44	44	43	36					
Days germinating.....	93	60	121	78	30	19	11	11	22	4	22	9	13		21	20	25	29	24	24	13					
Seeds germinated.....	78.8	65.9	90.3	39.2	53.6	19.6	16.4	19.6	29.3	5.6	36.7	21.9	40.6		39.7	55.6	54.4	60.4	50.0	72.7	65.0					
Per cent germination.....																										
Finger No. 4	June 14, 1922						July 20, 1922							July 21, 1922												
Date of sowing.....	47	136	111	27	89	45	56	51	70	62	54	53		83	23	50	31	21	42	20						
Seeds sown.....	27	29	31	38	40	21	32	30	45	58	39	34		21	35	22	20	25	21	20						
Days before germination...	74	35	55	70	69	42	25	39	30	15	23	27		44	28	39	41	26	30	55						
Days germinating.....	35	113	55	19	40	14	11	12	4	3	8	4		55	4	36	13	8	16	8						
Seeds germinated.....	74.5	83.1	49.5	70.4	44.9	31.2	19.6	23.5	5.7	4.8	14.8	7.6		66.3	17.4	72.0	41.9	38.0	38.0	40.0						
Per cent germination.....																										
Finger No. 5	June 14, 1922						July 20, 1922							July 21, 1922												
Date of sowing.....	122	116	122	53	109	38	61	77	92	17	53	42		40	60	21	34	39	23	23						
Seeds sown.....	24	29	33	31	40	30	74	43	30	27	30	43		26	24	26	29	29	26							
Days before germination...	64	33	48	49	12	43	17	14	32	14	43	1		35	40	18	11	48	1							
Days germinating.....	84	107	61	16	29	11	3	3	7	2	14	1		15	32	7	6	18	1							
Seeds germinated.....	68.9	92.2	50.0	30.2	26.6	28.9	4.9	3.9	7.6	1.2	26.4	2.4		37.5	53.3	33.3	17.6	46.2	4.4							
Per cent germination.....																										
Finger No. 6	June 14, 1922						July 20, 1922							July 21, 1922												
Date of sowing.....	60	98	94	60	74	6	75	49	63	53	60			25	48	28	40	32	24							
Seeds sown.....	31	29	27	34	37	60	29	0	73	30	51			29	22	24	29	25	26							
Days before germination...	48	35	51	45	23	31	63	0	25	68	55			33	27	35	43	30	10							
Days germinating.....	16	75	41	33	23	3	13	0	3	26	17			18	31	12	21	18	3							
Seeds germinated.....	26.7	76.5	43.6	55.0	31.1	50.0	17.3	0	4.8	49.1	28.2			72.0	64.6	42.9	52.5	56.3	12.5							
Per cent germination.....																										
Finger No. 7	June 14, 1922						July 20, 1922							July 21, 1922												
Date of sowing.....	55	78	114	45	51	2	92	72	52	55	41			21	34	29	23	31	25							
Seeds sown.....	25	35	31	34	37	30	23	37	58	30	28			96	40	24	22	21	22							
Days before germination...	59	40	49	26	16	1	42	2	21	48	32			1	60	31	18	23	31							
Days germinating.....	35	52	61	27	18	1	6	2	3	19	11			1	8	7	2	19	12							
Seeds germinated.....	63.6	66.7	53.5	60.0	35.3	50.0	6.5	2.8	5.8	34.6	26.8			4.8	23.5	24.1	8.7	61.3	48.0							
Per cent germination.....																										
Finger No. 8	June 14, 1923						July 20, 1922							July 21, 1922												
Date of sowing.....	100	73	61	84	58	59			22	50	27			26	33	21	16	31	34							
Seeds sown.....	27	29	38	37	21	23			41	21	50			29	21	24	37	20	22							
Days before germination...	39	43	70	71	39	25			32	42	14			43	43	24	34	33	23							
Days germinating.....	90	31	34	40	22	5			4	12	2			12	28	17	3	23	23							
Seeds germinated.....	90.0	42.5	55.7	47.6	37.9	8.5			18.2	24.0	7.4			46.1	84.9	80.9	18.8	74.2	67.6							
Per cent germination.....																										
Finger No. 9	June 14, 1922						July 20, 1922							July 21, 1922												
Date of sowing.....		83					67	74	52	45	43				50	29	17									
Seeds sown.....		25					23	30	43	27	34				22	27	31									
Days before germination...		42					41	43	30	20	36				18	13	22									
Days germinating.....		47					29	6	2	7	12				21	9	4									
Seeds germinated.....		56.6					43.3	8.1	3.8	15.6	27.9				42.0	31.0	23.5									
Per cent germination.....																										
Finger No. 10	June 14, 1922						July 20, 1922							July 21, 1922												
Date of sowing.....							44	38	73	44	43															
Seeds sown.....							25	23	50	34	23															
Days before germination...							38	20	19	49	32															
Days germinating.....							10	16	2	9	5															
Seeds germinated.....							22.7	42.1	2.7	20.5	11.6															
Per cent germination.....																										
Finger No. 11	June 14, 1923						July 20, 1922							July 21, 1922												
Date of sowing.....							58	88																		
Seeds sown.....							50	25																		
Days before germination...							24	52																		
Days germinating.....							8	9																		
Seeds germinated.....							14.0	10.2																		
Per cent germination.....																										

TABLE IV.—Summary of results on the rate and percentage of germination of seeds of abaca (variety Libuton) soaked in water of different temperature for varying periods.

	Variety: Libuton.												
	Temperature 30° C.												
	Durations of time soaking seeds in water.												
	1 min.	2 min.	3 min.	4 min.	5 min.	6 min.	7 min.	8 min.	9 min.	10 min.	12 min.	15 min.	20 min.
Date of sowing.....	August 12, 1922												
Seeds sown.....	200	200	200	200	200	200	200	200	200	200	200	200	200
Days before germination...	28	28	28	25	25	25	23	27	25	27	22	23	27
Days germinating.....	59	56	41	58	61	31	46	25	44	44	54	60	25
Seeds germinated.....	40	25	21	23	32	42	40	15	39	30	42	22	28
Per cent germination....	20	12.5	10.5	11.5	16.5	21.0	20.0	7.5	19.5	15.0	21.0	11.0	14.0
	Variety: Libuton.												
	Temperature 40° C.												
	Durations of time soaking seeds in water.												
	1 min.	2 min.	3 min.	4 min.	5 min.	6 min.	7 min.	8 min.	9 min.	10 min.	12 min.	15 min.	20 min.
Date of sowing.....	August 12, 1922												
Seeds sown.....	200	200	200	200	200	200	200	200	200	200	200	200	200
Days before germination...	27	21	21	22	23	21	25	23	24	23	23	35	38
Days germinating.....	50	56	62	56	54	56	21	57	47	41	52	43	42
Seeds germinated.....	32	26	40	36	24	44	21	36	20	34	25	25	19
Per cent germination....	16.0	13.0	20.0	18.0	12.0	22.0	10.5	18.0	10.0	17.0	12.5	12.5	9.5
	Variety: Libuton.												
	Temperature 50° C.												
	Durations of time soaking seeds in water.												
	1 min.	2 min.	3 min.	4 min.	5 min.	6 min.	7 min.	8 min.	9 min.	10 min.	12 min.	15 min.	20 min.
Date of sowing.....	May 19, 1922												
Seeds sown.....	200	200	200	200	200	200	200	200	200	200	200	200	200
Days before germination...	155	88	91	87	88	94	117	87	83	116	105	871	120
Days germinating.....	84	79	102	59	94	97	72	101	48	36	7	51	1
Seeds germinated.....	7	10	12	15	15	8	9	3	8	2	2	3	1
Per cent germination....	3.5	5.0	6.0	7.5	7.5	4.0	4.5	1.5	4.0	1.0	1.0	1.5	0.5
	Variety: Libuton.												
	Temperature 60° C.												
	Duration of time soaking seeds in water.												
	5 min.					10 min.							
Date of sowing.....	Jan. 27, 1923					Jan. 27, 1923							
Seeds sown.....	200					200							
Days before germination...	25					21							
Days germinating.....	17					20							
Sheets germinated.....	41					32							
Per cent germination....	20.5					32.0							

NOTE:—Seeds treated for similar time periods, at 70°, 80° and 100° gave a germination percentage of nil.

TABLE V.—Summary of results on the rate and percentage of germination of seeds of abaca (variety Libuton) as influenced by soaking in inorganic acids.

	Variety: Libuton.									
	Sulphuric acid.									
	Concentrated.				6-normal.			3-normal.		
	$\frac{1}{2}$ hour.	1 hour.	$2\frac{1}{2}$ hours.	3 hours.	$\frac{1}{2}$ hour.	1 hour.	3 hours.	$\frac{1}{2}$ hour.	1 hour.	3 hours.
Seeds sown.....	200	200	200	200	200	200	200	200	200	200
Days before germination.	32	23	26	25	21	26	48	23	30	30
Days germinating.....	23	50	1	15	54	48	15	59	75	43
Seeds germinated.....	5	15	1	2	30	23	7	40	24	7
Per cent germination...	2.5	7.5	0.5	1.0	15.0	11.5	3.5	20.0	12.0	3.5
	Nitric acid.									
	Concentrated.				6-normal.			3-normal.		
	$\frac{1}{2}$ hour.	1 hour.	$2\frac{1}{2}$ hours.	3 hours.	$\frac{1}{2}$ hour.	1 hour.	3 hours.	$\frac{1}{2}$ hour.	1 hour.	3 hours.
	$\frac{1}{2}$ hour.	1 hour.	$2\frac{1}{2}$ hours.	3 hours.	$\frac{1}{2}$ hour.	1 hour.	3 hours.	$\frac{1}{2}$ hour.	1 hour.	3 hours.
Seeds sown.....	200	200	200	200	200	200	200	200	200	200
Days before germination.	83	—	80	—	24	21	55	21	21	30
Days germinating.....	32	—	1	—	68	62	15	54	84	41
Seeds germinated.....	2	—	1	—	44	42	3	42	57	23
Per cent germination...	1.0	—	0.5	—	22.0	21.0	1.5	21.0	28.5	11.5
	Hydrochloric acid.									
	Concentrated.				6-normal.			3-normal.		
	$\frac{1}{2}$ hour.	1 hour.	$2\frac{1}{2}$ hours.	3 hours.	$\frac{1}{2}$ hour.	1 hour.	3 hours.	$\frac{1}{2}$ hour.	1 hour.	3 hours.
	$\frac{1}{2}$ hour.	1 hour.	$2\frac{1}{2}$ hours.	3 hours.	$\frac{1}{2}$ hour.	1 hour.	3 hours.	$\frac{1}{2}$ hour.	1 hour.	3 hours.
Seeds sown.....	200	200	200	200	200	200	200	200	200	200
Days before germination.	125	72	35	—	25	21	48	21	21	48
Days germinating.....	1	1	1	—	58	61	23	49	59	15
Seeds germinated.....	1	1	1	—	34	26	19	43	30	27
Per cent germination...	0.5	0.5	0.5	—	17.0	13.0	9.5	21.5	15.0	13.5

TABLE VI.—*Summary of results on rate and percentage of germination of seeds of abaca as influenced by passing through the alimentary canal of man and some animals.*

	(1) Variety: Libuton.						(2) Variety: Itom.		
	Fruit fed to chickens. ^a	Seeds passing through the alimentary canal of man.		Fruit with seeds fed to monkey.		Seeds without treatment.	Seeds passing through the alimentary canal of man.		Fruit with seeds fed to monkey.
		I	II	I	II		I	II	
Seeds sown.....	—	200	200	16	20	200	200	100	8
Days before germination....	—	31	25	42	39	33	17	17	18
Days germinating.....	—	16	23	11	11	15	9	9	9
Seeds germinated.....	—	77	74	4	2	34	96	46	2
Per cent germination.....	—	38.5	37	25	10	27	48	46	25

^a The seeds given to chickens were digested, so could not be planted.

TABLE VII.—*Summary of results on the rate and percentage of germination of seeds of Libuton abaca as influenced by the time of planting.*

	Variety: Libuton.		
	Months.		
	June.	July.	August.
Date of sowing.....	June 6, 1922	July 6, 1922	Aug. 8, 1922
Seeds sown.....	200	200	200
Days before germination.....	17	24	30
Days germinating.....	45	67	20
Seeds germinated.....	100	51	37
Per cent germination.....	50	25.5	18.5

NOTE:—200 seeds sown in each of the months from August, 1922, to February, 1923, inclusive, gave a germination percentage of nil.

ABSORPTION OF COMPLETE CULTURE SOLUTIONS BY ABACA ROOTS WITH REFERENCE TO GROWTH OF BRANCH ROOTS¹

By R. B. ESPINO and S. M. CRUZ

WITH ONE PLATE

The rate of absorption of complete culture solutions by the roots of abaca has hitherto been practically neglected. Copeland (1) appears to have been the only investigator to make any report on the subject. He reports that the "general average of daily absorption by the roots, including some which took up but very little water, is not quite one third of a gram". On three roots only, selected as especially active, he reports that the average daily absorption was 0.5084 gram of water.

In this report, the only one available on the subject, water was used as a medium in the absorption experiments. Pure water is unsuitable as a culture medium for higher plants as it does not supply the essential mineral elements.

Moreover, in order to become most beneficial or effective these elements should be not only in the right proportion or combination but should be supplied to the plant in the right concentration and amount. In view of these facts it was decided to make a study on the absorption of complete nutrient solutions by the roots of abaca plant. It was expected that from this study it might be possible to determine not only the amount of nutrient solutions an abaca plant absorbs in a given time but also the combination or proportion most readily absorbed.

The study here presented was conducted at the Abaca Nursery of the College of Agriculture, Los Baños, during the college year 1922 to 1923.

MATERIALS AND METHOD

CULTURE SOLUTIONS EMPLOYED

Eight different sets of molecular salt proportions, as shown in Table I, were used and each culture solution contained three salts. No two solutions had the same salt molecular proportions, but all of them had the same total concentration of 0.0245 gram-molecule (of all the salts taken together) per liter. This set is here designated as the 3-salt type.

In another set of cultures, which is here known as the 4-salt type, twelve culture solutions in different molecular salt proportions, but of the same concentration, were used (see Table II). Each culture solution had a total concentration of 0.0384 gram-molecule of all the salts per liter.

PREPARATION OF THE SINGLE-SALT STOCK AND CULTURE SOLUTIONS

In the preparation of the four single-salt stock solutions, distilled water and "Baker's analyzed" mono-potassium phosphate, calcium nitrate, magnesium sulphate, and ammonium sulphate, were used. Each of the four solutions was prepared in half-molar concentration. A few drops of a solution of ferric chloride were added to the stock culture solution.

¹ Thesis presented for graduation from the College of Agriculture, No. 152; Experiment Station contribution No. 124.

About 30 cubic centimeters of each culture solution were poured into a test tube. The test tube with its contents was weighed. About five centimeters in length of the tip of a root of abaca was immersed in the solution. In the first part of the study, each culture solution supplied to the root was renewed at the end of every two days.

OTHER PREPARATIONS

The roots were dug out of the ground, care being taken not to injure them. They were then washed with water, placed in test tubes for about three days to allow them to recover from the shock before being immersed in the solutions. At the end of the period the roots were immersed in the solutions, one root to each solution. The mouths of the test tubes were plugged with paraffined corks with holes in the center through which the roots were inserted. Then the preparations were covered with banana leaves so as to protect the roots from the drying influence of air, from the rain, and to keep them in darkness. For further protection from any possible disturbing effects of rain and sun a shed thatched with cogon leaves was put over the experiments. Care was exercised to effect renewal of solutions within the shortest time possible. The amount of solution absorbed was determined by weighing.

FURTHER PLAN OF EXPERIMENTS AND RESULTS

Eight roots from one hill of the Maguindanao variety of abaca were supplied with the eight culture solutions of the 3-salt type (see Table I). Each culture solution was tried on every root but on different days. Each of these solutions had a concentration of 0.0245 gram-molecule (of all salts taken together) per liter and was renewed at the end of every two days. A mass of numerical data on this part of the experiment was collected.

Each of the 12 culture solutions of the 4-salt type was tried also on every root of another set of twelve roots from the same hill. The solutions had a concentration of 0.0384 gram-molecule of the salts taken together per liter. The amounts of the culture solutions that entered the roots at the end of each experimental period were determined by weighing.

GROWTH OF BRANCH ROOTS

About two or three weeks after the experiments were started branch roots began to grow quite rapidly from the main root. Not all the *initial* roots employed in the experiments, however, developed these structures. Representatives of those that did develop them were gathered at the end of the experiments and are reproduced in Plate I.

Because of the appearance of branch roots in some of the culture solutions tested, the amount absorbed in a two-day period was considerably increased. These branch roots therefore may be considered as a *modifying factor* in the experiment.

Inasmuch as not all the data on hand were obtained as absorbed by a single root in a given time, it was absolutely impossible to interpret some of the results. For this reason it was decided to pick out from this mass of data absorption readings made during the experiments when the modifying factor mentioned above was not present. However, for the sake of comparison some of the absorption readings taken near the end of the experiments and when the modifying

factor was at work were included. The data referred to for the 3-salt culture solutions are given in Table III, and for the 4-salt culture solutions in Table IV. The corresponding weather records are also given in Tables III and IV.

DISCUSSION OF RESULTS

GROWTH OF BRANCH ROOTS, A DISTURBING, OR MODIFYING FACTOR

As originally planned the absorption-tests with 3-salt and 4-salt types of culture solutions were made in a *rotation*, or *cycle* system. With this arrangement it would have been possible to compare the rate at which the culture solutions in a set were taken in by the roots of abaca. Unfortunately, about two or three weeks after the experiments were started, branch roots were produced on the portion of the *initial* roots immersed in the solution. The disturbance caused by the branch roots upon the rate of absorption was not realized until the experiments were ended. When the data were studied it was then noticed that the growth of branch roots was usually accompanied by a corresponding increase in absorption hence the figures representing absorption made by one root were not comparable with the absorption by several roots. The data in Table II show that the five highest records on absorption (5.59, 3.41, 4.80, 4.02 and 3.73 grams) made *per root* were far smaller than the five highest records (15.93, 16.84, 12.49, 19.63 and 11.56 grams) made *per several roots*. A similar case may also be seen in Table IV. An attempt is here made to explain the probable cause and significance of the growth of the branch roots referred to above.

The data were obtained from which it could be determined whether or not the branch roots were the result of an unsuitable concentration of the culture solutions. But casual observations with water culture experiments in general seem to show that a profuse production of roots in solution was usually caused by a rather strong concentration of the solution, as Haberlandt (3) reports, a medium (solid or liquid) which is not in the right condition for a plant generally causes a profuse production of roots thereby increasing the surface for absorption. From this brief discussion it may be inferred that the production of growth of many branch roots in this study suggests that the concentration of culture solutions tested was rather strong for this plant. Further investigation in the same field should include tests of many different concentrations. The growth of branch roots opens a problem of physiologico-morphological nature, a study of which would have been attempted if time had permitted.

Another question may be raised as to whether or not the growth of the branch roots was due to a particular molecular proportion or combination of the salts employed. An examination of the data on hand, but not here published, and in Tables III and IV, may show that the different culture solutions tested were rotated among the different roots studied in such a way that it was impossible for a *particular* culture solution to have influenced the growth of branch roots from a *particular initial* root immersed in the solution. Moreover, our records show that not all the roots studied produced branch roots, though each of the *initial* roots was supplied with all the solutions in a set. It is, therefore, evident that the growth of the branches was not due to the molecular proportions or combinations of the salts nor to the presence of ammonium sulphate or of sodium nitrate in the media, as in both types of cultures some *initial* roots produced branches while others did not.

MAXIMUM ABSORPTION OF CULTURE SOLUTIONS

Although not exactly comparable, for the solutions were supplied to different sets of roots from the same clump of abaca, the data in Tables III and IV seem to show that the addition of ammonium sulphate in complete culture solutions made the intake of the latter by the roots relatively slower. On the assumption that the type solution most readily absorbed would give a maximum nutritive benefit to the plant the data given in the upper portion of Table III is of importance as the most rapid absorption of the culture solutions per root is recorded here.

It would not be safe to say that some of the culture solutions of the 3-salt type are most suitable for abaca. But the average daily records of absorption that can be derived from most of the results recorded in the upper portion of Table III were higher than the 0.5084 gram reported by Copeland as the daily average absorption of *water* by the roots which were selected as especially active. The average absorption of 3-salt culture solutions (in italics in the upper part of Table III) would be 2.155 grams a root a day, or about 300 per cent greater than the result reported by Copeland.

In the absence of any possibility of actually determining the amount of solution that the roots of an abaca plant, or a clump of the variety Maguindanao when grown in Los Baños absorbed in a given period of time, it becomes advisable to make the necessary computations. Granting that 2.155 grams was correct, the roots on the clump of abaca² studied would absorb 2353.26 grams, or about 2.4 kilograms of the culture solution in a day. A full grown plant² would absorb 230.585 grams or about 0.23 kilogram per day.

As regards the characteristics of G₃, a culture solution relatively the most readily absorbed of the 3-salt type, it appears that the solution referred to was composed of 0.0105 gram-molecule of mono-potassium phosphate; 0.0105 gram-molecule of calcium nitrate and 0.0035 gram-molecule of magnesium sulphate. It must be understood that this conclusion is only tentative. Further investigations should be conducted to fully establish its validity. Assuming that this conclusion is correct, it appears that the coconut (variety Laguna) and abaca of the variety studied differ from each other in salt requirement in that the coconut required ammonium sulphate in a completely balanced solution, while the abaca did not need it. These two plants seem to differ further from each other in that for a rapid absorption the coconut (4) required a culture solution, which contained an extremely low content of ammonium sulphate, mono-potassium phosphate or calcium nitrate and an extremely high amount of magnesium sulphate.

SUMMARY OF CONCLUSIONS

The limited amount of data on hand and the conditions under which this study was made warrant only the following tentative generalizations:

- (1) That a profuse growth of branch roots were produced when roots of abaca were supplied with 3-salt or 4-salt types of culture solutions tested.
- (2) That the ultimate cause of the growth of the branch roots was not determined, but that it appears entirely probable that a *particular* molecular proportion of the salts in the cultures was not responsible for their development.

² The clump of abaca studied had 9 large and 3 medium sized plants; 107 roots were found on a large plant and 41 roots on a medium sized plant.

(3) That two or more problems of a physiologico-morphological nature were brought out in this study.

(4) That the complete culture solutions with ammonium sulphate were in most cases less readily absorbed than the complete culture solutions without it—indicating that the salt was not needed by the plant.

(5) That the average daily absorption of the five highest readings obtained was 2.155 grams per root per day, or about 300 per cent more readily absorbed than water as reported by Copeland.

(6) That by computation, an abaca plant of the variety studied would absorb about 0.23 kilogram of the culture solution (found most readily absorbed) a day. On a similar basis the roots of the clump of the plant would take in about 2.4 kilograms of the solution in a day.

(7) That the culture solution most readily absorbed was characterized by having relatively medium amounts of either mono-potassium phosphate or calcium nitrate and a relatively high content of magnesium sulphate.

ACKNOWLEDGMENT

Thanks are due to Mr. Teofilo Novero, of the Department of Agronomy, for his help in checking the computations and to Mr. Moises Villaluz for making the drawings in Plate I.

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ILLUSTRATIONS

PLATE I

Roots of abaca that were immersed in culture solutions.

- | | | |
|-----------|---|---|
| Figure 1 | } | Branch roots comparatively few and some just beginning to appear. |
| Figure 2 | | |
| Figure 3 | | |
| Figure 4 | | |
| Figure 5 | | |
| Figure 6 | } | Profusely branched. |
| Figure 7 | | |
| Figure 8 | | |
| Figure 9 | | |
| Figure 10 | | |

TABLE IV.—Rate of absorption of complete 4-salt culture solutions by roots of abaca, variety *Ma guindanao*.^a

(Al readings in grams.)

Condition of roots.	Date	Root 1.	Root 2.	Root 3.	Root 4.	Root 5.	Root 6.	Root 7.	Root 8.	Root 9.	Root 10.	Root 11.	Root 12.	No. of days interval.
Single roots without large branches	Culture solutions.	A ₄	B ₄	C ₄	D ₄	E ₄	F ₄	G ₄	H ₄	I ₄	J ₄	K ₄	L ₄	
	<i>Date</i>													
	Oct 2-4	1.04	1.08	4.60	1.20	4.45	0.98	1.21	1.23	1.01	0.65	0.65	1.57	2
	Oct. 4-6	1.34	0.93	3.39	1.30	3.00	0.67	0.72	1.45	0.60	1.15	0.93	0.64	2
	Oct 6-8	0.77	1.43	1.54	1.32	1.07	0.64	0.41	1.54	1.49	0.68	2.40	0.66	2
	Culture solutions.	L ₄	A ₄	B ₄	C ₄	D ₄	E ₄	F ₄	G ₄	H ₄	I ₄	J ₄	K ₄	
	<i>Date</i>													
	Oct. 8-10	0.19	2.19	1.11	0.14	3.42	0.67	0.69	1.36	0.76	1.05	0.67	0.72	2
	Oct. 10-12	1.50	1.81	0.79	0.10	0.01	0.55	0.68	7.15	0.12	1.66	0.02	3.52	2
	Oct. 12-14	0.80	3.15	1.07	0.07	2.22	1.32	1.00	1.89	1.23	1.09	1.55	2.06	2
	Culture solutions.	C ₄	D ₄	E ₄	F ₄	S ₄	H ₄	I ₄	J ₄	K ₄	L ₄	A ₄	B ₄	
	<i>Date</i>													
With fully developed branch roots	Dec 1-3	2.45	1.25	0.64	2.95	1.01	0.84	1.01	0.84	0.11	0.11	0.16	2.86	2
	Dec. 3-5	0.44	4.44	6.17	1.09	0.85	3.37	1.31	1.67	0.93	0.06	0.70	0.13	2
	Dec. 5-7	0.06	7.81	3.49	7.56	2.60	1.15	3.41	2.51	0.50	0.08	0.31	0.53	2
	Culture solutions.	B ₄	C ₄	D ₄	E ₄	F ₄	G ₄	H ₄	I ₄	J ₄	K ₄	L ₄	A ₄	
	<i>Date</i>													
	Dec. 7-9	0.21	0.63	2.63	4.74	7.10	2.17	0.80	5.46	6.48	1.83	0.23	0.10	2
	Dec. 9-11	0.89	0.33	1.69	3.90	6.30	2.83	1.26	9.87	3.07	0.89	0.31	1.09	2
	Dec. 11-11	0.52	0.05	7.75	3.34	7.46	2.52	1.05	3.36	2.48	0.49	0.08	0.31	2

^a For climatic conditions see Table V.

TABLE V.—*Climatic conditions during experiments recorded in Tables III and IV.*

Temperature.				Date.
Maximum.	Optimum.	Minimum.		
30	28	26	Sunny	Oct. 2
30.1	28.1	26	Cloudy	
30.1	28.1	26	Cloudy	
30.1	27.5	25	Cloudy	5
30.1	27.5	25	Cloudy	6
30.1	27.5	25	Cloudy (slightly)	7
30	27.5	25	Very cloudy, some rain	8
30	27.5	25	$\frac{1}{2}$ Cloudy	9
30	27.5	25	$\frac{1}{4}$ Cloudy	10
29	27	25	Cloudy nearly all day	11
29	27	25	Cloudy nearly all day	12
30	28	26	$\frac{1}{2}$ Cloudy	13
30	26	26	$\frac{1}{4}$ Cloudy	14
27	26	25	Cloudy all day	Dec. 1
28	26.5	25	Cloudy	
27	25.5	24	Cloudy	3
27	25.5	24	Cloudy	4
27	25.5	24	Cloudy	5
28	26.5	25	$\frac{3}{4}$ Cloudy	6
29	26.5	24	$\frac{3}{4}$ Cloudy	7
28	25.5	23	$\frac{3}{4}$ Cloudy, no rain	8
27	25.5	24	Cloudy, occasional rain	9
29.5	27.3	25	$\frac{1}{5}$ Cloudy, no rain	10
29	26	23	$\frac{1}{5}$ Cloudy, no rain	11
27.5	26.3	25	Cloudy all day, light rain	12
28	25.5	23	Cloudy all day, no rain	13



PLATE I

SOIL MOISTURE REQUIREMENTS OF YOUNG ABACA PLANTS¹

By P. HERNAIS and R. B. ESPINO

Although abaca fiber is strictly a Philippine product and one of our most important exports, very little is known about the water requirements of the plant that produces it. The distribution of abaca in the Islands is limited by climate; it grows well in only a few provinces. Experience shows that the principal factor of climate that limits the distribution of this crop in this country is drought. Experience further shows that in many cases irrigation water has saved valuable abaca plantations during the dry season. But irrigation in many localities is either wanting or is very deficient. Moreover, the results obtained in the study here reported seem to show that this plant has an optimum requirement for soil moisture. It can stand neither too wet nor too dry a soil. For this reason to be able to use irrigation water economically and judiciously and to pick out suitable planting places a knowledge of the right amount of water needed by the plant is essential.

This study was undertaken with the aim of determining the soil moisture requirements of young abaca plants. The work was carried out only up to the seedling stage of the plant, hence, the results here presented are to be considered as preliminary only. They should be considered, also, as holding good only under the conditions of this experiment.

This study was conducted at the College of Agriculture, Los Baños, and covered a period of two years, from September, 1919, to September, 1921.

MATERIALS AND METHOD

THE SOIL

Kind and source.—The soil used was of the mellow loam type. It was taken from an alluvial deposit along the bank of Molawin Creek which runs through the College Farm and was fertile and fairly suitable for the normal growth of the abaca plant.

Amount and degree of saturation.—There were six sets of cultures in Trial I and six sets in Trial II. Each set had soil with a certain degree of water saturation. Each culture was run in quintuplicate and had fifteen kilograms of dry soil. The cultures that had soil saturated with water were considered 100 per cent saturation. The other degrees of saturation, 70, 50, 30, 20, and 10 per cent, were computed on this basis. Each degree of saturation was maintained by weighing each pot at intervals of forty-eight hours. The loss in weight was considered, although it is not accurate, as the amount of water absorbed or transpired by the plant for the period of time since previous weighing. The loss in weight of each culture was replaced with an equal amount of water. Thus the initial degree of saturation of each culture was maintained as closely as possible. There was a certain amount of error believed to be unavoidable due to the weight

¹ Thesis presented for graduation from the College of Agriculture, No. 153; Experiment Station contribution, No. 125.

of the plant in each culture. The results obtained in this study are of value as a preliminary study on the subject.

SEEDS AND SEEDLINGS

A sufficient quantity of seeds were collected from a bunch of ripe abaca fruit of an unknown variety in Indang, Cavite Province. These seeds were dried for a short time and sown in a germinating box containing alluvial soil. After about a month most of the seeds germinated. When the seedlings were about five centimeters in height, vigorous and uniformly developed ones were first grown in porcelain vessels containing two liters of soil each. These vessels had no drainage hole in the bottom. Each vessel of soil contained a certain degree of saturation. To reduce the rapid evaporation of water from the soil and to prevent rain water from getting into it the upper end of the container was sealed with paraffined paper. A short piece of glass tubing for the passage of air and of water whenever the latter was added was inserted through paper cover into the soil in the pot. The seedlings were allowed to grow in these containers until they were large enough to be transplanted into larger receptacles, in this case five-gallon kerosene cans. No further treatment was given to the plants, except to keep them under the shade and free from rain. The insect enemies of the plants were killed as soon as discovered on or about the plants.

EXPERIMENTS AND RESULTS •

EXTERNAL APPEARANCE OF THE PLANT

The external appearance of the plants was observed at the time of harvest. The data for both Trials I and II are given in Table I.

OTHER INDICATIONS OF RESULTS

Other indications of results were employed. These were (a) total growth, (b) height of plants, (c) number of leaves, (d) approximate area of leaves, (e) green weight of lamina and petiole, (f) diameter of stalk at base, (g) green weight of false stalk, and (h) green weight of whole top. The data under each of these criteria were gathered at the time of harvest.

Total growth.—Weekly measurements of the plant in each culture were made. The growth of each leaf was recorded. The sum of the growth of all the leaves in a week constitutes the total growth of the plant during the week. The sum of all weekly growths of each plant from the beginning until the end of the study forms the total growth of the plant.

Height of plants.—The total height of the plants from each culture was measured from the base of the stem to the top of the tallest leaf.

Number of leaves.—The leaves produced by each culture from the beginning to the end of the experiment were counted.

Approximate area of leaves.—The length and width of each leaf were measured and the product found of the dimensions. This product was considered the approximate area of the leaf. The sum of the approximate areas of all the leaves from each culture constitutes a result under this criterion.

Diameter of stalk at the base.—At about two centimeters above the surface of the soil in each pot, the diameter of the stalk of each culture was measured with calipers.

Green weight of lamina and petiole.—All the blades and petioles of the leaves from each culture were weighed soon after harvest.

Green weight of false stalk.—After cutting off the blades and the petioles of the leaves and removing them from the plant in each culture, the remaining portion of the stalk was weighed.

Green weight of whole top.—The numerical data in *e* were added to the corresponding data in *g*. This sum gives the weight of the whole top.

The data under these criteria are given in Tables II and III.

DISCUSSION OF RESULTS

EXTERNAL APPEARANCE OF PLANTS

As shown in Table II the results obtained from the cultures in Trial I were better than those from the corresponding cultures in Trial II. This difference was caused by the time of planting of the two trials. Trial I was started in the month of September when rain fell frequently, consequently the drying influence of the air was not great. The cultures in Trial II, however, were started during the summer when the temperature was fairly high. As a consequence, two out of five of the cultures provided with 50 per cent saturation in Trial II died, while none died in the similar cultures in Trial I. Moreover, the plants in Trial I were about sixteen months old at the time of harvest; while those in Trial II were harvested at the age of about nine months.

Two of the five cultures in saturated soil in Trial II died; none died from similar cultures in Trial I. However, the death of some of the cultures and the apparent stunted and yellowish condition of the others in Trial II, was only in very small part due to the drying influence of the air over the cultures. It was largely due to the presence of too much water in the soil which interfered with certain biological processes taking place in it. Because of lack in supply of oxygen in the saturated soil the respiration of the roots was probably interfered with. This lack in oxygen supply was the cause, also, of the stunted and yellowish condition of plants in Trial I.

Of all the cultures tested, those with 70 per cent saturation produced the most vigorous plants. The plants in these cultures had long, broad, and green leaves. They, also, had relatively large stalks. Four out of five cultures with 70 per cent saturation in Trial I produced suckers. No other cultures in either trial produced suckers.

These results confirm the experience of some abaca growers that this plant can not successfully be grown in regions where drought occurs at least once a year, or in soil saturated with water. Moreover, these results quantitatively establish the water need for the maximum development of the young plants when grown in pots containing alluvial soil and under the climatic conditions observed during the study.

OTHER INDICATIONS OF RESULTS

The cultures with 70 per cent saturation gave the highest results under all the criteria indicated in Table II. This was true both for Trials I and II as shown in Table III. The data in Table III show that under Trial I the 70 per cent saturation was 31 per cent superior to the 100 per cent saturation and 24 per cent better than the 50 per cent saturation. In Trial II the results obtained from the cultures with 70 per cent saturation were 59 per cent superior to those from

the *saturated soil* and 57 per cent over those obtained from the cultures that had *50 per cent saturation*.

The results in terms of the criteria, indicated in Tables II and III, fully confirm those in terms of the external appearance of the plant. These results further emphasize the superiority of the cultures with 70 per cent saturation over the other cultures supplied with more or less amount of water.

SUMMARY OF CONCLUSIONS

From the results of this study the following conclusions (under the conditions of the experiments) are fairly accurately established:

1. That of all the degrees of saturation of the soil in pots, 70 per cent promoted the best vegetative development of the young abaca plant. This was true with Trial I started during the rainy season as well as with Trial II started during the dry season.
2. That seedlings of abaca could not be grown even in a fertile soil when it had less than about 50 per cent saturation.
3. That the young abaca plant could not thrive well in alluvial soil saturated with water. This confirms the common observation or experience of abaca growers.
4. That the optimum moisture requirements of the young plant probably lies somewhere between 60 and 80 per cent saturation.

TABLE I.—*External appearance of the plants at the time of harvest.*

Saturation.	Culture No.	Trial I.	Trial II.
<i>per cent</i>			
100	A ₁	Yellowish narrow leaves	Yellow leaves; stunted in growth
	A ₂	Yellow leaves short and narrow; stalk short	Yellow leaves, narrow and short
	A ₃	Yellow leaves; stalk small and short	Dead
	A ₄	Yellow leaves; stalk small and short	Yellow leaves; small stalk
	A ₅	Yellow leaves long but narrow; stalk small and short	Dead
70	B ₁	Green leaves; vigorous and big stalk. Produced suckers	Green broad leaves; vigorous in growth
	B ₂	Green leaves broad and long; big stalk. Suckers are produced	Green and broad leaves; big stalk
	B ₃	Green leaves, broad and long; big stalk. Suckers are produced	Green leaves; big stalk
	B ₄	Green leaves, broad and long; stalk big	Green narrow leaves; big stalk
	B ₅	Green leaves, broad and long; suckers produced	Green leaves; stalk long
50	C ₁	Green leaves, wider than those from saturated	Dead
	C ₂	Green leaves, long but narrow	Greener leaves than those from saturated
	C ₃	Green leaves, long but narrow	Green leaves, long but narrow
	C ₄	Green leaves, narrower than those from 70 per cent saturation	Green leaves; bigger stalk than any in saturated
<i>a</i>	C ₅	Dead	Dead

a All cultures with 30, 20, and 10 per cent saturation, died.TABLE III.—*Relative value^a of average results from cultures with 100, 70 and 50 per cent saturation in both trials.*

Per cent saturation.....	Trial I.			Trial II.		
	100	70	50	100	70	50
Indications of results.						
1. Total growth, <i>cm.</i>	68	100	70	58	100	56
2. Height of plants, <i>cm.</i>	79	100	92	48	100	52
3. Number of leaves.....	87	100	100	92	100	70
4. Approximate area of leaves, <i>sq. cm.</i>	67	100	78	31	100	27
5. Green weight of lamina and petiole, <i>gm.</i> ..	64	100	72	24	100	35
6. Diameter of stalk, <i>cm.</i>	76	100	79	34	100	44
7. Green weight of stalk, <i>gm.</i>	59	100	59	19	100	28
8. Green weight of top, <i>gm.</i>	53	100	62	19	100	29
Average of relative values	69	100	76	41	100	43

^a The highest value under each criterion in either trial was considered 100 and the other values under the same indication of result were computed accordingly.

TABLE II.—Results obtained under different criteria at the time of harvest.

Trial I.

Degree of saturation.	Culture number.	Total growth.	Height of plants.	Number of leaves.	Area of leaves (approximate).	Green weight of lamina and petiole.	Diameter of stalk.	Green weight of false stalk.	Green weight of whole top.
<i>per cent</i>		<i>cm.</i>	<i>cm.</i>		<i>sq. cm.</i>	<i>gm.</i>	<i>cm.</i>	<i>gm.</i>	<i>gm.</i>
100	A1	341.7	78.5	20	2,169.75	36.2	3.10	127.4	163.6
	A2	242.9	63.3	22	1,455.6	28.5	2.80	90.8	119.3
	A3	292.8	72.4	22	1,463.1	49.5	3.10	115.3	164.8
	A4	248.1	59.7	26	1,075.55	34.4	2.40	53.0	87.4
	A5	243.1	68.5	16	1,630.05	77.4	2.65	222.5	200.0
70	B1	412.5	84.4	28	2,319.29	83.5	3.50	174.8	258.3
	B2	384.5	82.7	21	1,915.10	63.5	3.50	196.0	259.5
	B3	407.9	87.0	23	2,414.75	65.2	3.40	202.5	267.5
	B4	354.3	88.5	23	2,415.95	63.7	3.90	223.5	282.7
	B5	480.2	92.6	23	2,586.2	74.7	4.00	239.0	313.4
50	C1	327.4	78.5	23	1,963.55	50.3	3.05	130.6	180.9
	C2	130.2	74.0	26	824.10	50.6	2.15	59.4	110.0
	C3	333.5	80.3	25	2,197.92	56.2	3.40	133.8	190.0
	C4	347.1	86.1	24	2,344.97	43.2	3.30	162.1	205.0
	C5	dead	dead	—	—	—	—	—	—

Trial II.

100	A1	35.5	11.3	6	154.00	2.4	0.2	4.2	6.6
	A2	35.5	21.6	5	137.00	4.4	0.8	5.2	9.6
	A3	dead	—	—	—	—	—	—	—
	A4	43.7	19.3	6	168.85	2.2	0.5	3.6	5.8
	A5	dead	dead	—	—	—	—	—	—
70	B1	dead	dead	—	—	—	—	—	—
	B2	72.6	29.4	7	430.85	9.0	1.5	12.2	21.2
	B3	85.7	46.2	6	694.85	18.0	2.1	33.2	51.5
	B4	81.2	37.5	7	396.10	12.2	1.9	28.3	40.5
	B5	72.5	32.2	5	461.95	11.0	1.3	17.5	38.5
50	C1	dead	dead	—	dead	dead	—	—	—
	C2	30.6	13.7	5	124.2	1.9	0.6	3.3	5.2
	C3	40.8	14.0	3	132.75	4.2	0.6	5.3	9.5
	C4	60.5	29.3	5	142.32	7.1	1.05	10.4	17.5
	C5	dead	dead	—	—	—	—	—	—

^a All cultures with 30, 20, and 10 per cent saturation, and in Trial II 40 per cent also, died.

A PRELIMINARY STUDY OF THE SALT AND FERTILIZER NEEDS OF THE YOUNG ABACA PLANT¹

By R. B. ESPINO and B. O. VIADO

WITH ONE TEXT FIGURE

Although the abaca plant is generally grown in virgin soil, results from studies of its fertilizer requirements should be of some value. In tests of this kind with cultivated crops it has been shown that a judicious application of fertilizer was generally followed by a more productive yield, indicating that, though the quality and the quantity of the good ingredients might not be lacking, the proportion of the principal constituents might require adjustment. Also, if the same crop is harvested year after year from the same land as in the case of abaca, the steady though moderate reduction of the fertility of the field, will ultimately make the soil poor in mineral nutrients. Moreover, results of experiments on the salt and fertilizer needs of crops seem to show that they have individual requirements, not only in the kind of fertilizer material but also in the proportion and amount.

Evidence is not wanting which tends to show the influence of certain kinds and amounts of fertilizers on the production or development of certain structures in the plant body. No study of the abaca plant with the object of observing this influence has been made. Other plants, however, have been observed to respond favorably, and in some cases, extraordinarily, to the action of certain fertilizers. For instance, it has been found in this College that an increased production of oil could be obtained as a result of the application of fertilizers to the soil where the peanut is grown. Sugar cane has been found to produce more sucrose when supplied with certain kind and proportion of fertilizers.

One of the objects of the present study was to find whether or not application of a certain fertilizer to the young abaca plant would be accompanied by an increased yield of fiber or by the production of fiber of certain special quality. Another object was to find fertilizer combinations that would promote the most vigorous vegetative growth of the crop.

The present study was conducted at the College of Agriculture for the period from June, 1920, to September, 1921. The study was made on two series of cultures. The first series was supplied with certain chemicals with the intention of obtaining quick results. The second series was supplied with ordinary commercial fertilizers.

MATERIALS AND METHODS

THE SOLID MEDIUM

In both series of cultures the soil used was clay loam and was taken from a field east of the Seed Laboratory which had been previously planted to cassava and had never received any application of fertilizer. The amount of soil required for each of the series of cultures was collected, thoroughly pulverized and mixed, before putting it in the pots² and pilones³. Each pot was filled to about two centimeters from the brim.

¹ Thesis presented for graduation from the College of Agriculture, No. 154; Experiment Station contribution, No. 126.

² Earthen flower pot No. 6, capacity 2 liters, used for Series I.

³ Ordinary earthen receptacle for sugar in the Philippines; conical shape, broad end at top; narrow end at the bottom with drainage hole; capacity 45 liters, used for cultures in Series II.

THE SEEDS AND SEEDLINGS

On July 4, 1920, and again on January 6, 1921, ripe fruit of abaca of an unknown variety were secured from Indang, Cavite. The seeds were separated from the fruit and washed with water to remove the pulp.

They were then germinated in seed plots which were kept moist by watering them every other day. After about a month the seeds germinated and when the seedlings had attained a height of about five centimeters, or possessed four visible leaves, uniformly developed seedlings were transplanted to the pots, one seedling to each pot.

THE NUTRIENT MEDIA

In both series of cultures the triangular method of apportioning the nutritive constituents proposed by Schreiner and Skinner⁴ was followed. In Series I, 19 cultures out of 153 in a triangular set were used and each culture was run in triplicate. The triplicate cultures are designated by *a*, *b*, *c*. Three control cultures were employed. Table I shows the proportions and actual amounts of the chemicals, potassium acid phosphate, calcium nitrate, magnesium sulphate, used. The amounts shown in the table were supplied to the plant in four different applications at bi-weekly intervals.

In Series II, nine cultures were used; four cultures without fertilizers, for the control. The cultures were run in quadruplicate as designated by *a*, *b*, *c*, *d*, and were supplied with two sets of fertilizer combinations; one is here designated as the *ammonium set* and the other as the *nitrate set*. The ammonium set was supplied with potassium sulphate, double superphosphate, and ammonium sulphate. The nitrate set had the same commercial fertilizers except that sodium nitrate was substituted for the ammonium sulphate. Table II shows the proportions and actual amounts of the fertilizers employed. The fertilizers were applied only once to the pilones and the application was made soon after the seedlings were properly set in the pilones.

CARE OF CULTURE

While the cultures in Series I were in progress, oiled paper was placed on the surface of the soil in each pot to prevent it from becoming too dry and to suppress the growth of weeds. To further check the rapid evaporation of water from the pot and from the plant and to protect the seedlings from the destructive violence of strong winds, a frame over which cheese cloth was stretched, was placed about a meter above the plants.

For the cultures in Series II, where the commercial fertilizers were used banana leaf sheaths cut in suitable sizes were employed to protect the seedlings from the intensity of the sunlight and the hard wind. The cultures were watered and cultivated when necessary.

EXPERIMENTS AND RESULTS

SERIES I, SALT SOLUTION SERIES

For the cultures in Series I, where the salt solutions were employed as the nutritive media, the following criteria of results are employed; namely, (1) growth in height, (2) weight of green top, (3) approximate area of leaves, and (4) number of roots.

⁴ Schreiner O., and Skinner, J. J. Ratio of phosphate and potassium on absorption and growth. *Botanical Gazette* 50: 1-30. 1910.

Growth in height.—The weekly growth increment was measured once a week from a base mark on the surface of the ground to the tip of the youngest leaf in each culture. The numerical data for this are given in Table III.

Weight of green top.—The weight of green top was determined in each culture. The top from each culture was severed from the roots and weighed. Table III shows the weights of green tops.

Approximate area of leaves.—The approximate area of all leaves on each plant was determined. The length from the upper end of the petiole up to the tip of the leaf was multiplied by the width of the widest part of the leaf; the product represents the approximate area of each leaf.

The sum total of the areas of all the leaves from each culture is the approximate area indicated in Table III.

Number of roots.—The roots from each plant were counted. Only those which originated from the rhizome were included. The data are shown in Table III.

SERIES II. THE COMMERCIAL FERTILIZERS SERIES

Four indications of results are employed for the cultures where the commercial fertilizers were used. They are (1) length of tallest leaf, (2) diameter of stalk, (3) length of all leaves combined, and (4) the approximate area of all leaves combined.

Length of all leaves combined.—The length of all the leaves was also determined. From the base mark made, each leaf was measured separately. The length from the base mark up to the tip of every leaf was taken and the lengths of all the leaves were combined.

DISCUSSION OF RESULTS

THE SALT SOLUTION SERIES

From unpublished data the writers gathered that young abaca plants started from seeds are quite variable in size and behavior, although grown under similar environmental conditions. In spite of the influence of the fertilizers added to the cultures in the present study these natural individual variations in development were observed. Effort was made to correct this as much as possible by running each culture in triplicate. Since the data shown in Table III seem to show some discrepancy, a brief discussion is here given on the column, "corrected". This column shows the sum total of all separate data under the four criteria employed in this series of cultures.

The corrected data in both series of cultures as shown in Table III and Table IV were obtained in the same manner. The sum of the numerical data of the criteria employed in either series was divided by the number of living plants in each culture. The quotient obtained was then multiplied by the number of dead plants and the product was added to the original data.

Examining the figures for the sum total it will be seen that Cultures 7, 8, 10, and 11, especially the 7 and the 11 cultures gave good yield under the criteria of results here employed. To these four cultures may be added Culture 18, which, though affected by certain unknown disturbing factors not within control, gave a good yield. As it is not expected that many good cultures will be discovered in a limited set of cultures, such as here tested, two exceptionally good ones were

selected and their characteristics as regards the fertilizer materials studied. These cultures are characterized by having the following salt proportions:

		KH_2PO_4	$\text{Ca}(\text{NO}_3)_2$	MgSO_4
Culture 7		2	8	2
Culture 11		4	7	1

From the data, it is evident that for the best growth and development of the young abaca plant when grown in clay loam soil and under climatic conditions observed, a rather heavy application of calcium nitrate was needed. As for the other salts, potassium acid phosphate and magnesium sulphate, only a very moderate application of each was needed in order to obtain a good vegetative development of the plant. Culture 7 was 264 per cent better than the control.

THE COMMERCIAL FERTILIZER SERIES

In common with many other agricultural crops, abaca plants are materially influenced by the application of ammonium sulphate. Sodium nitrate was not so beneficial as ammonium sulphate. The plants in the ammonium sulphate set were much more vigorous and had greener leaves than those grown in cultures supplied with sodium nitrate. About 50 per cent of the seedlings supplied with sodium nitrate died, while of those which were supplied with the ammoniacal form of nitrogen, only two died. These facts tend to show the possibility of improving the vegetative growth of the plant by proper application of fertilizer.

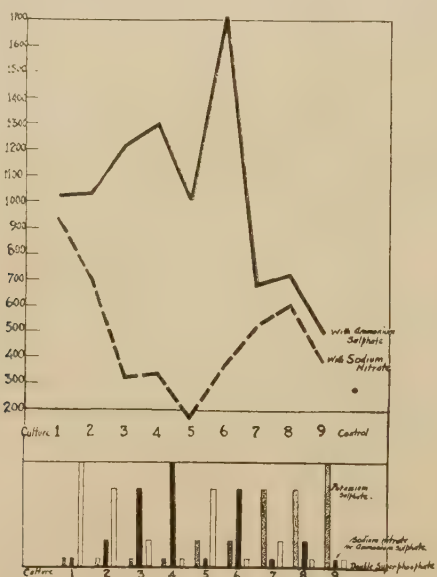


Figure 1. Graphs showing the comparative results from the different fertilized cultures; the ammonium set compared with the nitrate set.

It may even improve the quality and increase the quantity of the fiber produced. This supposition will require much experimentation before a reliable conclusion can be arrived at. The data under four different criteria of results are summarized in Table IV. The data in this table are graphed in Figure 1. This graph shows clearly and conclusively the superiority of the ammonium set of cultures over the nitrate set. Further examination of this graph shows that in the ammonium set the good results were obtained from Cultures 3, 4, and 6. These cultures are characterized by having relatively high amount of ammonium sulphate and moderate amount of either potassium sulphate and double superphosphate.

It appears from the curve representing the results obtained from the cultures supplied with sodium nitrate, that this form of nitrogen is unsuitable for this plant under the conditions of the present experiment.

Culture 10 (the control) as shown in Table IV and in Figure 1 gave much lower yield than any fertilized culture in the ammonium set. There were, however, four cultures in the nitrate set that gave a lower yield than the control. The best fertilized culture in the ammonium set was 383 per cent better than the control.

SUMMARY OF CONCLUSIONS

From the results obtained in this study it appears that the following generalizations may be drawn:

1. That the results from the present study are only preliminary in nature and hold good only under the soil and climatic conditions to which the young abaca plant used were subjected.
2. That the young abaca plant was benefited with a certain application of either calcium nitrate or ammonium sulphate.
3. That the ammonium sulphate was a far better source of nitrogen for this plant than sodium nitrate. For this reason, this plant belongs in the same category as the rice plant, tobacco plant, and several other agricultural crops as regards the source of nitrogen requirement.
4. That about 50 per cent of the seedlings out of the 36 cultures supplied with the sodium nitrate died during the very early stage of growth.
5. That in order to improve the nutritive condition of the loam soil generally used for abaca plantations and to promote a vigorous vegetative development of the young abaca plant a moderate application of either potassium sulphate and double superphosphate should be accompanied with a relatively heavy application of ammonium sulphate. The amount of ammonium sulphate should be from two to three times as much as either the potassium sulphate or double superphosphate.

TABLE I.—Proportions and amounts of the three salts employed. 1333.3 cc. of solution to each culture with the molar concentration indicated below.

Culture No.	Proportions of salts.			Volume of molar stock salt solutions.		
	KH ₂ PO ₄	Ca(NO ₃) ₂	MgSO ₄	KH ₂ PO ₄	Ca(NO ₃) ₂	MgSO ₄
1	1	1	10	0.0041	0.0041	0.0410
2	1	4	7	0.0041	0.0164	0.0287
3	1	7	4	0.0041	0.0287	0.0164
4	1	10	1	0.0041	0.0410	0.0041
5	2	2	8	0.0082	0.0082	0.0388
6	2	5	6	0.0082	0.0205	0.0246
7	2	8	2	0.0082	0.0328	0.0082
8	3	3	6	0.0123	0.0123	0.0246
9	4	1	7	0.0164	0.0041	0.0287
10	4	4	4	0.0164	0.0164	0.0164
11	4	7	1	0.0164	0.0287	0.0041
12	5	2	5	0.0205	0.0082	0.0205
13	5	5	2	0.0205	0.0205	0.0082
14	6	3	3	0.0246	0.0123	0.0123
15	7	1	4	0.0287	0.0041	0.0164
16	7	4	1	0.0287	0.0164	0.0041
17	8	2	2	0.0328	0.0082	0.0082
18	10	1	1	0.0410	0.0041	0.0041
19	Control					

TABLE II.—*Proportions and actual amounts of the three commercial fertilizers added to the cultures in the ammonium set and nitrate set.*

Culture No.	Proportions and actual amount.			Actual amounts of fertilizers.					
	K	N	P	Ammonium set.			Nitrate set.		
	Potas- sium sulphate.	Ammo- nium sulphate.	Double super- phos- phate.	Potas- sium sulphate.	Sodium nitrate.	Double super- phos- phate.			
	gm.	gm.	gm.	gm.	gm.	gm.	gm.	gm.	gm.
1	1	1	20	2.5	8.7	94.0	2.5	8.8	94.0
2	1	5	15	2.5	43.5	70.5	2.5	44.0	70.5
3	1	15	5	2.5	130.5	23.5	2.5	132.0	23.5
4	1	20	1	2.5	174.0	4.7	2.5	176.0	4.7
5	5	1	15	12.5	8.7	70.5	12.5	8.8	70.5
6	5	15	1	12.5	130.5	4.7	12.5	132.0	4.7
7	15	1	5	37.5	8.7	23.5	37.5	8.8	23.5
8	15	5	1	37.5	43.5	4.7	37.5	44.0	4.7
9	20	1	1	50.0	8.7	4.7	50.0	8.8	4.7
Control	0	0	0	0	0	0	0	0	0

TABLE IV.—*The sum of all numerical data for the sodium nitrate and ammonium sulphate series.*

Culture No.	Ammonium sulphate series.		Sodium nitrate series.	
	Actual.	Corrected.	Actual.	Corrected.
1	7550	10066	7145	9593
2	7699	10265	3599	7197
3	9146	12194	1597	3193
4	13046	13046	827	3308
5	10206	10206	1063	1417
6	17269	17269	2905	3873
7	6870	6870	5262	5262
8	8212	8212	5252	7003
9	6324	6324	2707	3609
Control	4501		4501	

TABLE III.—Numerical data for the triplicate sets of cultures of the abaca plants (Series I) supplied with a 3-salt culture solution.

Culture No.	Salt proportions.			Height of tallest leaf in cm.			Green weight of top in grams.			Approximate area of leaves sq. cm.			Number of roots.			Total.	
	KH ₂ PO ₄	Ca (NO ₃) ₂	MgSO ₄	a	b	c	a	b	c	a	b	c	a	b	c	Actual	Corrected.
1	1	1	10	a	16	20	a	7	12	a	88	253	a	11	9	416	554
2	1	4	7	a	29	21	a	22	11	a	431	216	a	15	7	752	1035
3	1	7	4	8	23	22	1	14	16	46	318	292	6	10	10	766	766
4	1	10	1	15	22	a	4	12	a	106	310	a	7	8	a	484	484
5	1	2	8	25	26	21	22	15	13	415	323	359	11	11	10	1230	1230
6	2	5	5	29	17	a	31	14	a	630	165	a	10	10	a	906	1208
7	2	8	2	25	31	20	25	28	11	405	561	688	15	15	11	1835	1835
8	3	3	6	22	24	25	10	15	27	262	440	476	10	11	11	1333	1333
9	4	1	7	19	29	21	12	21	12	276	451	241	13	8	8	1111	1111
10	4	4	4	21	34	25	10	41	11	242	701	356	11	15	8	1475	1475
11	4	7	1	23	29	27	19	19	25	428	334	531	12	9	15	1531	1531
12	5	2	5	17	27	a	12	21	a	215	335	a	11	13	a	651	868
13	5	5	3	a	25	27	a	21	18	a	442	296	a	12	10	851	1134
14	6	3	3	a	16	24	19	5	17	a	161	372	a	5	13	613	814
15	7	1	4	27	18	21	19	4	9	366	112	422	9	12	8	1997	997
16	7	4	1	14	11	25	3	2	15	114	56	430	9	7	9	1695	695
17	8	2	2	24	30	15	12	31	7	346	616	178	8	11	9	1311	1311
18	10	1	1	19	23	28	10	14	24	304	457	737	6	8	11	1641	1641
19	Control			19	18	15	7	8	6	217	220	160	6	11	8	695	695

a The plant died. Nothing was harvested.

FOLIAR TRANSPIRING POWER OF DIFFERENT VARIETIES OF ABACA GROWN AT THE COLLEGE OF AGRICULTURE¹

By PERPETUO GAVARRA AND R. B. ESPINO

WITH TWO TEXT FIGURES

This paper presents the first set of results obtained from a series of studies in finding the varieties of abaca, grown in the College of Agriculture, in Los Baños, that might be best adapted to a region having prolonged drought. The conclusion that may be derived from the present study, although valuable, is not comprehensive as only twelve varieties were investigated. The method employed is known as the cobalt-chloride test for the determination of the transpiring power or the natural ability of the leaf of plant to give off water vapor in spite of the absence of influence of some of the factors in the environment of the plant.

EXPERIMENTAL PROCEDURE AND RESULTS

The varieties of abaca (*Musa textilis*) used were Maguindanao, Tañgoñgon, Pulahan, Libuton, Boñgulanon, Punacan, Baguisanon-Basag, Baguisanon-Lawaan, Sinaba, Agutay, Putian, and Itom.

A fully grown stalk of each of the twelve varieties under observation was used. In testing the foliar transpiring power, a cobalt-chloride slip about 30 millimeters in width was placed in contact with the upper or lower surface. Five tests were made on the upper surface of every leaf of each plant,—from the oldest to the youngest. In each test the time-period was recorded with the use of a stop-watch and the temperature with a thermometer. Before making the tests in this study the cobalt-chloride slips were standardized in the laboratory. Since the slips here employed were all from a rather large piece of filter paper impregnated with the salt it was not surprising, as was found, that they had the same coefficient.

By Livingston (1) and others the final result of each test is called the *index of transpiring power* of the leaf. By this is meant the power of the leaf surface to give up water vapor compared with a similar power of the standard water surface, that is, the time period required to effect a color change of the cobalt-chloride slip placed over a standard evaporating surface (water-saturated porous clay covered with a millimeter of air) divided by the length of time required to make the change of color of the same slip when placed upon the surface of a leaf of the same temperature. In this experiment the temperature of the air in the laboratory when the standardization of the slips was made was not the same as that observed around the leaf; it was, therefore, necessary that the equivalent vapor-pressure of water shown in a table published by Livingston and Shreve 2, be employed in the computation of the index of the transpiring power sought.

How the computations were made are described by Trelease (3) as follows:

In one of the tests, for a certain slip of cobalt paper the time-period for the color change on the leaf was 77 seconds when the air temperature was 23.7° C., corresponding to a vapor pressure of water of 21.76 millimeters. Since the slip of cobalt paper had required 31.9

¹ Thesis presented for graduation from the College of Agriculture, No. 155; Experiment Station contribution, No. 127.

seconds for the change over the standard surface when the temperature was 27.4°C ., corresponding to a vapor pressure of 27.10 millimeters, the time-period required for the change over the standard surface at the temperature of the leaf would have been $31.9 \times 21.10 \div 21.76$, or 40 seconds. In this test the index of transpiring power, being the time required for the change over the standard surface divided by the time required for the change over the leaf at the same temperature, was 40 divided by 77 or 0.52.

The numerical data on the relative ability of the upper and the lower epidermis of each of the leaves on one mature plant of each of the abaca varieties studied, with the corresponding air temperature during the experiment are not here given.

But the method of computation as quoted from Trelease was followed and the data of the *index of foliar transpiring power* obtained are given in Table I only as averages of similar data, that is, from the quintuplicate trials as well as the average of the data for the upper and lower epidermis of the same leaf. Likewise, the averages for all the leaves (upper and lower) on each of the plants studied are shown in the same table. These averages for different varieties studied are graphed in Figure 1.

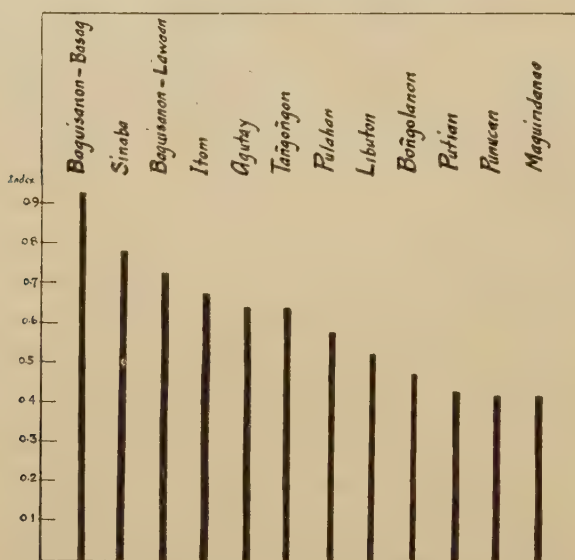


Figure 1. Showing the comparative foliar transpiring power (average of averages) of the different varieties of abaca studied; arranged in the descending order.

The bi-hourly march of the transpiring power of a middle-age leaf of abaca, variety Libuton, was also determined. The tests were from six o'clock in the morning one day until six in the morning of the next. Five readings were taken

within each bi-hourly period of observation. The *index of the foliar transpiring power* as computed and the averages together with the records of the *transpiring power* of air are graphed in Figure 2.

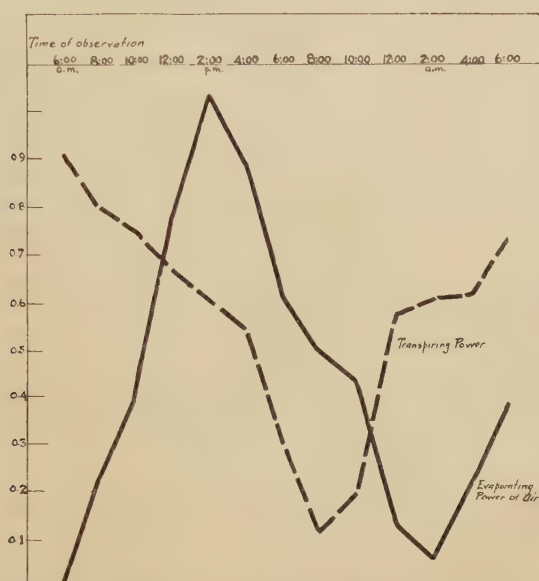


Figure 2. Bi-hourly march of foliar transpiring power of Libuton variety of abaca compared with the records of evaporation.

DISCUSSION OF RESULTS

Accepting the idea with many investigators that the index of transpiring power as put forward by Livingston (1) is a measure of the power of leaves to supply moisture to the surrounding air, and considering as correct the belief that "the reciprocal of this index is a measure of the power of leaves to retain water against the drying influence of the surroundings" (4), it may follow, therefore, that the data on hand found with the use of the cobalt-chloride method may lead to the discovery of the relative resistance to drought of the varieties studied. With this idea in mind and considering the results in terms of averages, we may now begin to examine the data on hand. Care is taken in this report not to go into minute details because a certain amount of the human factor or equation is partly responsible for slight discrepancies that may be found in the data on hand.

Examining the data in Table I we find that the indices of foliar transpiring power of all the varieties studied are from about two to about five times higher in the lower leaf epidermis than in the upper epidermis. This difference is no doubt due to the presence of either all, or most, of the stomata in the lower surface of the leaf of abaca.

The data in Table I seem not to warrant a generalization as regards the relative transpiring power of the leaves of different ages of each plant. For in some varieties the transpiring power increased as the youngest visible leaf was approached. In others, however, the reverse was observed. As regards the average of averages of results shown in Table I and graphed in Figure 1, it is interesting to note that the varieties Baguisanon-Basag, Sinaba and Baguisanon-Lawaan showed a transpiring power relatively greater than in the other varieties. The varieties Boñgulanon, Putian, Punacan, and Maguindanao have the lowest record. In accordance with our working theory, the last four varieties mentioned have relatively the greater power to retain water against the drying influence of the environment. From this characteristic it may follow that these varieties might be suitable for planting in places where the drying influence of the air is great.

But the Maguindanao has been reported by Aldaba (5) as "easily injured by prolonged dry weather". It becomes now necessary to attempt to explain the two apparently contradictory facts.

The Maguindanao variety has mature leaves larger and broader than those of any of the varieties studied. In point of number it is one of the varieties that have the greatest. Its surface of exposure, then, is relatively large. For this reason, although it possesses a relatively low index of foliar transpiring power, the total amount of water that leaves its body is correspondingly large. This fact together with our knowledge that the plant possesses a scanty root system is probably mainly responsible for the failure of the variety to withstand prolonged dry weather. The other varieties are not defective in their root system. Their respective *index* as graphically illustrated in Figure 1 may serve as a guide of their relative drought-resistance. The varieties Itom, Agutay, Tañgoñgon, Pulahan and Libuton are neither too free nor too conservative in giving off water in the air. For this reason they may be adaptable to places where extremes of weather are not experienced.

The bi-hourly march of foliar transpiring power of the twelve varieties has also been studied. Graphs in Figure 2 show that the *index* was highest during the very early morning hours. It gradually fell until eight o'clock in the evening, at which time it began to rise again until the early hours of the next day. Compared with the *evaporating power of the air* (see Fig. 2) its rate was almost inversely proportional. The highest record for evaporation, however, was obtained during the very early afternoon hours and the lowest was at two o'clock in the morning. Since the records for the evaporation of the present study are about the same as obtained by Trelease (3) in his study of the transpiring power of the leaves of the coconut on the College Campus and since the curve for the transpiring power of the leaves of abaca fits quite closely a similar curve for the coconut, the two plants would seem to be similar in this respect. Their graphs of the hourly (bi-hourly in the case of abaca) march of transpiring power resemble in a general way similar graphs for other kinds of plants studied by the cobalt-chloride method.²

² See Bakke (5); Trelease (4); Trelease and Livingston (7); Bakke and Livingston (8).

SUMMARY OF CONCLUSIONS

(1) The present study should be considered as only preliminary in nature. A much more thorough study should be made on the transpiring power of the leaves of abaca of the different varieties under different climatic conditions.

(2) The index of foliar transpiring power of the twelve varieties of abaca studied was from about two to about five times greater for the lower surface than for the upper surface.

(3) Due to some disagreement in the numerical data obtained, further experiments should be made on the relative rate of transpiring power of the different leaves of each plant.

(4) The Baguisanon-Basag, Sinaba and Baguisanon-Lawaan varieties had the highest *index of transpiring power*. The varieties Boñgulanon, Putian, Punacan and Maguindanao had the lowest *index*.

(5) The first three varieties in (4) may be considered as relatively the least resistant to drying influence of the environment. With the exception of Maguindanao the last four varieties may be resistant to drought. In the field the Maguindanao variety has been found not resistant to the drying influence of the weather. This is due to a large crown and a limited root-system, conditions which are not found in most of the abaca varieties known.

(6) The march of the transpiring power during the day of a full grown leaf of the Libuton variety seems to agree with that of the coconut palm both in rate and in fluctuations.

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TABLE I.—Averages of several similar data on the index of foliar transpiring power of abacas.

Leaf No.	Names of Varieties.								
	(a) Maguindanao.			(b) Tañogñgon.			(c) Pulahan.		
	Upper sur-faces.	Lower sur-faces.	Average of two sides.	Upper sur-faces.	Lower sur-faces.	Average of two sides.	Upper sur-faces.	Lower sur-faces.	Average of two sides.
I	0.23	0.45	0.34	0.266	0.874	0.57	0.336	0.71	0.523
II	0.22	0.432	0.326	0.20	0.974	0.587	0.252	0.874	0.563
III	0.24	0.528	0.284	0.216	1.00	0.608	0.25	0.896	0.573
IV	0.276	0.828	0.552	0.31	0.994	0.652	0.306	0.952	0.629
V	0.346	0.996	0.671				0.30	1.004	0.652
Averages for all the leaves.			0.435	0.604			0.588		
Leaf No.	(d) Libuton.			(e) Boñgulanon			(f) Punacan.		
	Upper sur-faces.	Lower sur-faces.	Average of two sides.	Upper sur-faces.	Lower sur-faces.	Average of two sides.	Upper sur-faces.	Lower sur-faces.	Average of two sides.
	Upper sur-faces.	Lower sur-faces.	Average of two sides.	Upper sur-faces.	Lower sur-faces.	Average of two sides.	Upper sur-faces.	Lower sur-faces.	Average of two sides.
I	0.158	1.098	0.608	0.16	0.664	0.412	0.176	0.582	0.374
II	0.312	0.722	0.517	0.16	0.708	0.434	0.202	0.728	0.465
III	0.164	1.098	0.631	0.152	0.576	0.364	0.256	0.552	0.402
IV	0.236	0.938	0.587	0.188	0.954	0.571	0.236	0.668	0.452
V				0.222	1.038	0.530	0.224	0.668	0.496
Averages for all the leaves.			0.588	0.462			0.439		
Leaf No.	(g) Baguisanon-Basag.			(h) Baguisanon-Lawaan.			(i) Sinaba.		
	Upper sur-faces.	Lower sur-faces.	Average of two sides.	Upper sur-faces.	Lower sur-faces.	Average of two sides.	Upper sur-faces.	Lower sur-faces.	Average of two sides.
	Upper sur-faces.	Lower sur-faces.	Average of two sides.	Upper sur-faces.	Lower sur-faces.	Average of two sides.	Upper sur-faces.	Lower sur-faces.	Average of two sides.
I	0.324	1.706	1.015	0.314	1.475	0.894	0.322	1.594	0.958
II	0.35	1.538	0.944	0.296	1.412	0.854	0.32	1.426	0.873
III	0.302	1.582	0.942	0.30	1.498	0.899	0.296	1.572	0.934
IV	0.266	1.216	0.736	0.30	1.432	0.866	0.32	1.53	0.925
V							0.30	1.504	0.902
Averages for all the leaves.			0.703	0.703			0.798		
Leaf No.	(j) Agutay.			(k) Putian.			(l) Itom.		
	Upper sur-faces.	Lower sur-faces.	Average of two sides.	Upper sur-faces.	Lower sur-faces.	Average of two sides.	Upper sur-faces.	Lower sur-faces.	Average of two sides.
	Upper sur-faces.	Lower sur-faces.	Average of two sides.	Upper sur-faces.	Lower sur-faces.	Average of two sides.	Upper sur-faces.	Lower sur-faces.	Average of two sides.
I	0.428	0.886	0.657	0.334	0.816	0.574	0.206	1.184	0.695
II	0.302	0.96	0.631	0.242	0.634	0.438	0.202	1.03	0.616
III	0.346	0.984	0.665	0.252	0.658	0.455	0.218	1.086	0.552
IV	0.296	1.236	0.766	0.238	0.556	0.397	0.286	1.19	0.738
V	0.28	0.72	0.50	0.218	0.484	0.356	0.256	1.242	0.749
Averages for all the leaves.			0.643	0.443			0.670		

COMPARATIVE STUDY OF FIBERS PRODUCED BY SIX VARIETIES OF ABACA WHEN GROWN IN LOS BAÑOS: I¹

By R. B. ESPINO and FELIX ESGUERRA

WITH SEVEN PLATES

There are about one hundred varieties of the abaca plant growing in different parts of the Archipelago. Some seventy of these varieties are now under culture at this College. Most of these varieties had been fruiting for more than a year and were, therefore, suitable for such a study as is here reported.

The present study deals mainly with the microscopical structures of the fibers and fiber-cells in the leaf-sheaths from the stalks of six varieties of abaca. It also deals with the comparative strength of the fibers from these varieties. The primary object was (1) to establish any striking peculiarities of the fibers of the different varieties and (2) to compare the strength of the fibers from the different varieties when grown side by side under Los Baños conditions of soil and climate. The results from this study may be of value in the determination, not only of the comparative merits of the varieties as regards the yield of fiber, but also in the establishment of a permanent system of varietal nomenclature.

This study was carried out at the College of Agriculture, Los Baños, during the college year 1921-1922.

MATERIALS, METHODS AND RESULTS

VARIETIES USED

The varieties used in this study were: Boñgulanon, Itom, Libuton, Maguindanao, Punucan, and Sinaba. These are grown side by side in the Lower Nursery of the College. From Vista's (1) description, the following is quoted:

a. *Musa textilis* Née. Var. *Boñgulanon* (Saleeby) C. A. 1029.—Produces 15-29 plants to a hill, but 4-10 are medium and 10-15 are small, somewhat spreading in the hill, fast grower, generally inclined to lowland habitat. False stem is 3.7-4.6 m. high, 15-20 cm. diameter at base and 8.9-10 cm. diameter at top.

This variety is from La Carlota Experiment Station. It is rarely found outside of Mindanao. Edwards and Saleeby (2) pointed out that it has very white, strong, heavy, and easy to extract, fibers.

b. *Musa textilis* Née. Var. *Itom in Albay, Samorong Itom in Ambos Camarines*. C. A. 4293.—Producing 3-8 plants in a hill but 1-2 are medium and 1-3 are small, somewhat spreading in the hill; fast grower, generally erect. In the College Nursery this variety produces 30-35 plants but 5-10 are medium and 10-15 small ones which are crowded in the hill. False stem is 3.34-4.50 m. high, 16-20 cm. diameter at enlarged base and 11.14 cm. diameter at top.

This variety is from Lamao Experiment Station. It is considered one of the best varieties in Albay, for it produces good and strong fibers.

c. *Musa textilis* Née Var. *Maguindanao* (Saleeby).—Produces 10-17 plants to a hill but 4-5 are medium and 4-8 are small, spreading in the hill; fast grower, began flowering at the age of 1 year and 4½ months after the sucker is transplanted, of lowland habitat. False stem is 3.30-4.30 m. high, 20-22 cm. diameter at enlarged base and 8-12 cm. diameter at top; this grows into a very big plant and as tall as 5.5 m. if planted on rich alluvial soil but it flowers when only 2.5 m. high if grown on heavy soils. This variety is from Lamao Experiment Station.

¹ Thesis presented for graduation from the College of Agriculture, No. 156; Experiment Station contribution No. 128.

This variety is cultivated throughout Davao. It produces few roots so it is easily affected by drought and easily fallen by wind.

d. *Musa textilis* Née Var. *Libuton* (Saleeby) C. A. 100.—Produces 3-6 suckers per hill, but 1-2 are small, crowded in the hill; erect, fast and hardy growers. False stem 3.75-4.75 m. high, 16-20 cm. diameter at enlarged base and 10-11 cm. diameter at top.

This variety is from Mindanao. Its fiber is lighter than those of Boñgulanon, Maguin-danao and Tañgongon; so it is not very popular. It is an early variety bearing flowers at the age of 14½ months.

The two other varieties were not studied by Vista but were described by Edwards and Saleeby (2).

Their description, together with the results of our observation on these two varieties at the College, will give the following characteristics:

e. *Musa textilis* Née Var. *Punucan*.—C. A. 10276. This variety is exactly like *Libuton* in all characteristics, with the exception of color and the number of stalks in a hill. It is often mistaken for *Libuton*.

In the College Nursery, this variety produces 6 to 10 plants in a hill, but 3 to 4 are medium, and 3 to 6 are small; generally erect. False stalk is 2.6 to 2.8 meters high, 13 to 15 centimeters in diameter at the enlarged base and 7 to 9 centimeters in diameter at the top.

This variety is from La Carlota Experiment Station.

f. *Musa textilis* Née Var. *Sinaba*, C. A. 10310.—The thickness of the stalk compares favorably with that of *Libuton* but is shorter.

In the College Nursery, this variety produces 8 to 12 stalks per hill; 4 to 5 are medium and 4 to 7 are small. False stalk is 2.4 to 2.7 meters high, 14 to 16 centimeters in diameter at enlarged base and 6 to 9 centimeters in diameter at the top.

This variety is from La Carlota Experiment Station.

MICROSCOPIC STUDY

Microtome sections were made from the outermost leaf-sheaths one-half meter from the base and two centimeters from either edge. The different types of fibers found in the section were drawn with the aid of a camera lucida. The drawings are shown in Plates I to VI.

Also, with the aid of a camera lucida and after maceration, cells obtained from the fibers (1) either at edge of the outermost leaf-sheath, (2) near the outer epidermis two centimeters from the edge, (3) from the "bridge", and (4) from the inner epidermis of the sheath, were drawn longitudinally. The dimensions of these cells were measured, but the numerical data are not here published. Plate VII shows a portion of median longitudinal sections of fiber-cells. Average dimensions of fiber-cells are given in Table I.

GROSS AREA OF FIBER STRANDS

The gross cross-sectional area of each of the fiber strands drawn and obtained from the different varieties studied was determined with the use of a planimeter. The data are given in Table II.

TENSILE STRENGTH OF FIBERS

Materials used.—The fibers from the edges and middle portion of each of the sheaths from the largest fruiting stalk of each variety were extracted with the use of an ordinary stripping machine. The fibers were dried in the air and their tensile strength determined.

The tests.—An apparatus, similar to the one employed by Espino (3), was used in testing the tensile strength of each sample which consisted of five fibers, 50 centimeters long. One end of each sample was attached to a clamp at the upper end of the apparatus; to the lower end of the sample, another clamp was attached. To this end, weights were gradually added. The smallest weights used were small lead shot. When the samples were about to break, care was taken to increase the load by adding shot one by one. Only the tests where the break of the fibers occurred simultaneously and somewhere between the two ends of the sample, were considered good; the others were discarded. The weight of the sample of fiber in each good test was determined. The breaking stretch of each sample of fiber was also recorded. The records of the actual breaking strength, as well as those of the computed tensile strength, of each sample from the six varieties were secured. But only the data in terms of averages are here published (see Table III.) The tensile strengths (averages) of the fiber samples reduced to a gram basis are presented in Table IV. The data on the average breaking stretch of fibers from the middle and edges of each leaf-sheath are given in Table V.

DISCUSSION OF RESULTS

THE FIBER STRANDS

Comparative gross area.—As shown in Table II the cross-sectional areas of different fiber structures in different parts of a leaf-sheath differ from one another considerably. The smallest fiber strand recorded in the table had a cross-sectional area of 0.0003 square millimeter and the largest was 0.00031 square millimeter. The fiber strands composed of purely sclerenchymatous cells are usually much smaller than those with conducting structures. The first six strands in Table II are purely sclerenchymatous cells. Strands No. 7 had very little conducting tissues, and as reported by Espino (3) are the largest solid fiber obtained in stripping.

Comparing the total cross-sectional areas of the six varieties, the Boñgulanon, Sinaba, and possibly the Libuton, had the largest. The smallest area was obtained from Itom. This same order of results was obtained after taking the total area of the first seven strands in each variety. It is obvious (considering only the fibers that usually come out solid, not broken after stripping) that the Boñgulanon, Sinaba and the Libuton varieties produce coarser fibers than the Itom, Maguindanao and the Punucan varieties. Boñgulanon fibers were the coarsest and those of Itom were the finest.

Appearance in cross-section.—Upon examination of Plates I to VI it may be seen that Figures 1 to 6, inclusive, in each plate, are drawings of the cross-sections of purely sclerenchymatous strands. These, together with strands shown in Figure 7, constitute the bulk of the fibers found in the market. The sclerenchyma strand near the phloem portion of the vascular bundle, Figure 8, is usually broken into two or more pieces in stripping. In the market, these pieces were found by Espino mixed with the purely sclerenchyma fibers. The fiber strands, which in part, form the big vascular bundles at the "bridge," or in the inner portion of the leaf-sheath, (Figs. 8 to 11), are usually thrown away with the waste in stripping. The fiber-cells constituting these strands are relatively large and have comparatively large lumina and thin walls. Moreover, as shown in the

figures the sclerenchyma strands in each vascular bundle are of crescent shape. They are not cylindrical in cross section. They are, therefore, as reported by Espino and as observed in this study, weak fibers,

Of the six varieties studied, the fiber-cells from Sinaba have strikingly large lumina. The fiber-cells of the Boñgulanon, on the other hand, are provided with apparently relatively thick walls and very narrow lumina. The fibers from the other four varieties are of the same general appearance, as seen in cross section.

THE FIBER-CELLS

The length.—Table I shows that the fiber-cells from the edges or near the edges of the leaf sheath of each of the Boñgulanon, Maguindanao, Punucan, and Sinaba varieties are shorter than the fiber-cells of the same variety but obtained from the so-called *discarded portion* of the leaf-sheath. In Table I the records representing the fiber-elements from the discarded portion are those that were obtained from the “bridge” and from the portion of the sheath near the inner epidermis.

The average lengths of the fiber-cells obtained from the different parts of a leaf-sheath of Libuton are about the same. The same is true with the fiber-cells of Itom.

Considering the average length of the fiber-cells of the leaf-sheath, Punucan had the shortest, being about 2.6 millimeters. The Boñgulanon had the longest fiber-cells, 5.3 millimeters. This was followed by Itom. The average lengths of the fibers of Libuton, Maguindanao, and Sinaba were about the same.

Gross diameter.—Considering only the fiber-cells from the edges and near the edges of the leaf-sheath, the largest gross diameter (average) of fiber-cells was obtained from the fibers of Boñgulanon. It was 0.0196 millimeter. The next in size of gross diameter was of Itom. It had 0.0142 millimeter as an average of ten measurements. The diameters of the fiber-elements of the other varieties stand between the maximum (0.0196 millimeter) and the minimum (0.0142 millimeter) here reported.

Thickness of walls.—The thickness of the walls of the cells from the edges and near the edges is considerably greater than the thickness of the walls of the fiber-elements from the *discarded portion* of the leaf-sheath. This is true in all the varieties here reported. This fact in part accounts for the relative weakness of the fibers in the *discarded portion* of the leaf-sheath.

On an average, the Boñgulanon had the thickest walls of the fiber elements. The maximum thickness was 0.00801 millimeter. The thinnest wall was found in Sinaba fibers, 0.004795 millimeter in the fibers obtained from near the outer epidermis about two or three centimeters from the edges of the leaf-sheath.

Diameter of lumen.—The data in Table I conclusively show that the fiber-cells from the *discarded portion* of the leaf-sheath (C and D in the table) have the widest diameter of the lumen. The maximum recorded is 0.02765 millimeter and the minimum is 0.0132 millimeter.

The diameters of the lumina of the fiber-elements found in the portion of the leaf-sheath that gives good fiber were found only 0.0078 millimeter as the maximum, and 0.00257 millimeter the minimum. These data are also shown in Table I. This table further shows that Itom and Sinaba had the widest lumina of all the varieties studied. The Boñgulanon possesses fiber-cells with particularly

narrow lumina. In terms of average of ten measurements, the lumina of fiber-cells from the edge of the leaf-sheath of Boñgulanon had a diameter of 0.00275 millimeter only.

TENSILE STRENGTH OF FIBERS

The actual data.—By actual tensile strength of fibers is here meant the weight that will be required to break samples consisting of five average-sized fibers, 50 centimeters in length.

All the tensile strength tests made on fibers obtained from the different leaf-sheaths of each variety show that the fibers from the four or five leaf-sheaths somewhere between the outermost and the innermost leaf-sheaths of one trunk were the strongest. Espino in 1915 obtained similar results and had explained the case by assuming that the fibers from the few outermost leaf-sheaths were relatively brittle due to a more thorough impregnation of silica and other substances in the walls of the fiber-elements. Such impregnation of silica makes the fiber relatively weak. On the other hand, the fibers from the few innermost leaf-sheaths of each trunk are finer than those from the outer leaf-sheaths. The cell walls are probably not thoroughly developed or lignified.

Table IV shows that the fibers from the middle (or midrib) portion of the leaf-sheath were invariably stronger than those from the edges. As will be seen in the latter part of this paper, this difference was due to the difference in the weights of the sample from the edges and those from the midrib. The fibers from the midrib were coarser and consequently heavier and had probably a greater cross-sectional area of walls than the fibers from the edges. But when the records of strength of the fibers were reduced to a gram basis, as will be seen, the fibers from the edges come out stronger.

As was to be expected on account of the extraordinary thickness of the walls and narrow lumina of the fiber-elements in the Boñgulanon, this variety, of all the varieties tested, produced the strongest fibers. The strongest sample of fiber from this variety required a weight of 17.47 kilograms to break it. The average of averages of fibers from the edges and those from the middle portion of the leaf-sheath was 9.86 kilograms for Boñgulanon, 8.22 kilograms for Sinaba, 7.88 for Libuton and a little over 6.5 kilograms for each of the remaining four varieties.

Incidentally, it should be remarked that the Boñgulanon had the most leaf-sheaths; leaf-sheaths that produced fibers that could be tested. The Sinaba fibers, although relatively strong, are produced from only 14 leaf-sheaths. The rest of the varieties studied had about an equal number of leaf-sheaths from one stalk.

The calculated data.—As stated in the preceding paragraph, if the breaking load were computed to one-gram sample, the fibers from the edges would, as was experienced by Espino, come out stronger than those from the midrib of each leaf-sheath. Evidently this expectation was fulfilled as shown by the data in Table IV. Inspection of this table shows that the Sinaba fibers were the strongest of the lot. The average strength (119.71 kilograms) was, however, only a little stronger than Punucan fibers (119.3 kilograms). Itom, Libuton, and Maguin-danao produced fibers of about the same average strength. In terms of one-gram samples the fibers of Boñgulanon gave an average strength of 104.84 kilograms, only. This variety, then, had the weakest fibers in this respect.

Table IV further shows that the fibers obtained from a few leaf-sheaths somewhere between the outermost and the innermost leaf-sheaths were the strongest. This result points out the special preference or suitability for cordage purposes of the fibers from the few inner leaf-sheaths referred to.

BREAKING STRETCH OF FIBERS

Table V shows that the records of the breaking stretch of fibers obtained from the different leaf-sheaths of one stalk of each of the varieties studied do not differ much from one another. However, the breaking stretch of the fibers extracted from the two or three outermost leaf-sheaths as well as the breaking stretch of about the same number of innermost leaf-sheaths was almost always shorter than that for the outermost and the innermost leaf-sheaths.

The general close similarity of the data in the table seems to suggest either that the fibers of the different varieties have about the same stretching power, or that the method used for recording or testing the stretch needs improvement. Further studies should be carried out before any safe generalization can be drawn on the comparative stretch of fibers from the different leaf-sheaths in one stalk or from stalks of different varieties of abaca.

SUMMARY OF CONCLUSIONS

From the results obtained in this study, the following conclusions may be drawn:

1. The Boñgulanon and Sinaba varieties had relatively coarse fibers. With these two varieties, Libuton may be included. Itom had relatively fine fiber.
2. Boñgulanon had the longest fiber-cells; Punucan, the shortest, considering only the fibers at the edges of near the edges of the leaf-sheath.
3. Boñgulanon had the widest fiber-cells, followed by Itom; Punucan had the smallest. The other varieties had about the same, a size intermediate between Boñgulanon and Punucan.
4. The walls of the fiber-cells near the outer epidermis were very much thicker than those of fibers from the *discarded portion*. Boñgulanon had the thickest walls and Sinaba, the thinnest.
5. The lumina of fiber-cells from the so-called *discarded portion* of the leaf sheath had the widest diameter. The fiber elements of Boñgulanon had relatively narrow lumina.
6. The fibers from the outermost and innermost leaf-sheaths were weaker than those from the leaf-sheaths lying between. Boñgulanon fiber was the strongest in terms of actual breaking load. Sinaba fiber was next in strength, Itom had the weakest. When the strength of the fiber was considered in terms of a unit weight of the sample, Sinaba and Punucan fibers were the strongest and Boñgulanon the weakest.
7. A more satisfactory method of recording the tensile stretch of fibers should be devised.

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ILLUSTRATIONS

PLATE I

Cross section of fibers from Boñgulanon variety of abaca.

PLATE II

Cross section of fibers from Itom variety of abaca.

PLATE III

Cross section of fibers from Libuton variety of abaca.

PLATE IV

Cross section of fibers from Maguindanao variety of abaca.

PLATE V

Cross section of fibers from Punucan variety of abaca.

PLATE VI

Cross section of fibers from Sinaba variety of abaca.

Each plate has 13 or 14 figures as follows:

Figs. 1 to 8. Fibers between the bridge and the outer epidermis.

Figs. 9 to 10. Fibers at "bridge".

Fig. 11. Fiber at "bridge" extending downwards.

Figs. 12 to 13 or 14. Fibers between "bridge" and inner epidermis.

PLATE VII

Portions of the fiber cells from different varieties of abaca.

- A. Cells from fibers at either edge of the outermost leaf-sheath.
- B. Cells from fibers near the outer epidermis two centimeters from the edge.
- C. Cells from fibers at bridge.
- D. Cells from fibers obtained near the inner epidermis.

TABLE I.—Average dimensions of fiber-cells.

Origin of fiber-cell.	Variety name.	Dimensions of fiber-cells.			
		Gross diameter.	Diameter of lumen.	Thickness of cell wall.	Length.
		<i>mm.</i>	<i>mm.</i>	<i>mm.</i>	<i>mm.</i>
A. From edges of leaf sheaths	Boñgulanon.....	.0180	.00275	.007625	5.229
	Itom.....	.0149	.00620	.005750	5.226
	Libuton.....	.0177	.00257	.006115	4.676
	Maguindanao.....	.01535	.00295	.006200	4.528
	Punucan.....	.0142	.00285	.005725	2.591
	Sinaba.....	.01408	.00340	.005340	4.324
B. From outer epidermis, one inch from edges	Boñgulanon.....	.0196	.00358	.008010	5.308
	Itom.....	.0172	.00715	.004975	4.975
	Libuton.....	.01645	.00505	.005600	3.857
	Maguindanao.....	.02525	.00453	.005360	3.821
	Punucan.....	.01450	.00372	.005390	3.170
	Sinaba.....	.0174	.00780	.004795	3.204
C. From "bridge"	Boñgulanon.....	.02250	.01320	.004650	6.997
	Itom.....	.02180	.01305	.004375	4.981
	Libuton.....	.03300	.02405	.004525	4.481
	Maguindanao.....	.02370	.01650	.003600	6.162
	Punucan.....	.02870	.02145	.003625	6.091
	Sinaba.....	.02430	.01675	.003675	6.184
D. From portion near inner epidermis	Boñgulanon.....	.02320	.01325	.004975	7.377
	Itom.....	.02820	.02165	.003275	5.120
	Libuton.....	.02820	.02090	.003650	4.834
	Maguindanao.....	.03500	.02765	.003675	8.398
	Punucan.....	.02900	.02250	.003250	7.198
	Sinaba.....	.02192	.01530	.003305	6.140

TABLE II.—Cross sectional area of schrenchyma strands obtained from different parts of a sheath of each of six varieties of abaca.

Strand No.	Boñgulanon	Libuton.	Maguindanao	Itom.	Sinaba:	Punucan.
	<i>sq. mm.</i>	<i>sq. mm.</i>	<i>sq. mm.</i>	<i>sq. mm.</i>	<i>sq. mm.</i>	<i>sq. mm.</i>
1	.00048	.00051	.00128	.00033	.00048	.00031
2	.00051	.00061	.00159	.00048	.00106	.00061
3	.00316	.00214	.00173	.00049	.00122	.00112
4	.00485	.00353	.00616	.00088	.00267	.00265
5	.01612	.00763	.01371	.00158	.00716	.00869
6	.05469	.04110	.02622	.02204	.05216	.02982
7	.06477	.05102	.04143	.02323	.06214	.03214
8	.05243	.05283	.02733	.02884	.05408	.03674
9	.03918	.01355	.00571	.00747	.01306	.01049
10	.05804	.05541	.03535	.04888	.05302	.03953
11	.05173	.04871	.04498	.05720	.06224	.03761
12	.01429	.00261	.00279	.00133	.00787	.00694
13	.00526	.00673	.00302	.00343	.00953	.00504
Total.	.36551	.28638	.21130	.19618	.32669	.21089
Total from 1-7 incl..	.14458	.10554	.09212	.04903	.12689	.07534
Total from 8-13 incl.	.22093	.188084	.11918	.14715	.19980	.13535

TABLE III.—Average of tensile strength tests consisting of five fibers, each 50 centimeters in length.

Leaf-sheath No.	Boigulanon.		Itom.		Libuton.		Maguindanao.		Punuan.		Sinaba.	
	Middle.	Edge.	Middle.	Edge.	Middle.	Edge.	Middle.	Edge.	Middle.	Edge.	Middle.	Edge.
	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.
1	11.96	8.52	7.95	4.99	8.15	7.03	6.95	4.95	7.70	6.00	10.96	6.98
2	11.76	8.30	—	7.58	10.10	6.83	6.46	5.74	8.27	5.19	11.20	7.49
3	11.62	8.60	8.91	7.17	9.62	8.03	7.93	5.52	8.61	6.99	10.53	8.78
4	10.78	8.80	—	6.13	12.35	7.96	7.63	5.96	9.34	6.46	11.50	8.67
5	13.35	9.09	11.19	6.94	9.54	6.79	8.25	6.20	10.22	6.31	12.22	7.88
6	13.24	8.38	10.88	5.64	11.88	6.99	9.05	7.51	10.92	6.59	13.35	7.72
7	13.52	9.00	12.10	6.55	11.27	8.74	10.62	7.14	8.75	7.54	9.64	8.85
8	14.55	8.53	9.32	6.21	12.40	8.57	11.73	7.89	9.79	7.38	11.15	7.78
9	15.46	11.54	11.00	7.13	10.79	7.45	12.73	8.40	9.19	5.75	10.55	6.89
10	17.47	9.73	9.00	6.93	9.61	7.11	11.84	7.91	7.52	6.36	9.22	5.95
11	13.53	7.72	8.92	6.30	10.12	6.06	7.95	6.65	8.43	5.62	6.67	5.65
12	15.49	8.75	8.54	5.36	9.54	8.32	6.44	6.48	7.48	5.33	6.86	4.40
13	12.71	9.06	6.53	5.25	9.42	8.09	9.56	5.22	6.89	4.88	7.09	4.59
14	11.64	9.19	5.65	4.29	8.84	6.49	7.54	5.74	7.33	4.68	5.10	2.58
15	11.74	7.19	5.80	2.40	7.64	5.52	5.02	6.52	6.87	4.50	—	—
16	10.87	7.40	2.90	2.91	5.39	3.20	5.94	4.38	3.94	3.60	—	—
17	9.56	5.67	2.37	2.97	8.02	4.80	4.56	4.81	2.82	2.13	—	—
18	10.80	3.95	2.11	3.02	5.21	4.48	4.23	4.14	—	—	—	—
19	8.78	4.19	—	—	4.12	2.86	3.26	3.57	—	—	—	—
20	8.50	6.26	—	—	—	—	3.57	3.46	—	—	—	—
21	3.82	3.07	—	—	—	—	—	—	—	—	—	—
Average...	11.96	7.76	7.70	5.43	9.16	6.60	7.56	5.91	7.89	5.61	9.72	6.73
Average...	9.88		6.56		7.88		6.73		6.75		8.22	

TABLE IV.—Average tensile strength of one gram sample of fiber 50 centimeters long.

Leaf-sheath No.	Boñgulanon.		Itom.		Libuton.		Maguindanao.		Pamucan.		Sinaba.	
	Middle.	Edge.	Middle.	Edge.	Middle.	Edge.	Middle.	Edge.	Middle.	Edge.	Middle.	Edge.
1	81.56	111.49	104.91	103.02	79.97	99.43	93.59	113.65	106.41	103.30	87.16	107.43
2	109.62	139.44	—	128.63	84.00	93.96	95.61	117.69	119.52	100.24	102.90	104.33
3	93.98	117.93	105.89	105.57	104.99	126.16	110.54	110.62	118.51	128.81	92.24	117.81
4	93.16	148.03	—	123.07	110.18	113.34	102.44	120.88	121.61	121.21	99.09	114.51
5	110.27	114.99	112.50	122.69	182.00	93.69	105.32	120.47	116.05	124.36	104.99	114.52
6	100.69	136.96	103.68	108.00	107.08	98.65	100.50	125.97	116.47	125.25	111.97	117.26
7	99.27	130.05	121.99	121.04	89.72	126.58	105.70	129.60	94.26	127.16	127.55	127.38
8	107.94	119.23	108.65	109.00	109.44	123.00	118.37	126.75	111.47	126.96	115.87	133.30
9	97.46	133.98	126.56	151.05	88.07	117.10	111.51	133.78	128.56	144.98	133.05	154.40
10	108.31	129.02	123.89	144.13	101.40	122.54	115.31	129.98	127.77	132.39	124.10	144.62
11	105.03	119.34	117.25	140.78	89.09	109.45	94.41	131.52	111.90	128.71	108.30	149.83
12	115.81	109.65	131.94	108.62	104.19	144.04	85.29	142.37	117.91	127.35	115.22	141.37
13	102.33	100.89	99.77	140.41	113.05	125.36	96.46	99.88	140.05	125.71	134.75	142.40
14	92.71	106.57	112.41	120.08	117.80	168.23	108.86	136.70	141.88	152.07	109.16	116.64
15	94.59	115.17	127.67	103.62	123.11	145.64	101.59	124.77	134.11	137.59	—	—
16	86.09	118.49	89.67	109.30	95.39	101.23	107.64	116.84	81.16	105.88	—	—
17	86.34	94.26	58.52	104.21	107.67	146.93	103.20	148.30	79.51	77.26	—	—
18	98.24	60.41	68.06	118.19	98.17	156.23	85.62	115.90	—	—	—	—
19	84.67	86.23	—	—	131.17	133.71	87.21	89.89	—	—	—	—
20	74.72	100.07	—	—	—	—	89.90	107.87	—	—	—	—
21	76.55	91.96	—	—	—	—	—	—	—	—	—	—
Average...	96.16	113.53	107.08	122.59	101.92	123.43	100.95	122.17	115.71	122.90	111.88	127.55
Av. of av...	104.84	—	114.83	—	112.67	—	111.56	—	119.30	—	119.71	—

TABLE V.—Average breaking stretch of fibers from the middle and edges of the different leaf-sheaths from a stalk of six varieties of abaca.

Leaf-sheath No.	Bongulanon.		Itom.		Libuton.		Maguindano.		Pumutan.		Sinaba.	
	Middle.	Edge.	Middle.	Edge.	Middle.	Edge.	Middle.	Edge.	Middle.	Edge.	Middle.	Edge.
1	mm. 12.4	mm. 11.8	mm. 9.4	mm. 11.3	mm. 11.0	mm. 11.4	mm. 9.8	mm. 10.5	mm. 7.8	mm. 8.4	mm. 12.2	mm. 10.0
2	12.2	12.8	—	12.2	12.2	11.0	9.8	10.8	8.2	7.6	9.6	11.0
3	11.6	11.8	11.4	11.2	12.8	12.0	9.2	11.0	9.2	9.6	11.8	11.2
4	12.2	12.8	—	11.6	12.8	13.0	11.0	10.0	8.4	9.8	12.2	10.6
5	12.4	12.6	11.4	12.4	12.2	11.4	11.0	11.0	11.4	11.0	12.4	12.0
6	12.6	12.1	12.8	11.0	10.2	11.2	11.2	12.0	11.8	11.4	10.6	10.8
7	12.2	12.2	12.6	12.2	12.3	11.6	11.0	11.4	12.4	11.8	12.4	13.4
8	11.8	13.2	12.0	10.2	12.6	12.0	12.6	12.0	12.0	12.0	12.8	11.2
9	13.8	13.4	12.2	12.2	11.6	11.4	12.8	12.0	12.4	11.4	12.6	12.8
10	13.5	13.8	11.2	13.2	12.8	12.0	11.8	12.0	12.4	11.6	13.2	12.6
11	12.8	12.8	12.8	11.6	12.6	11.4	12.4	11.0	12.8	12.4	12.4	12.2
12	13.0	13.6	12.0	11.8	12.6	13.4	12.4	11.8	12.4	11.8	11.0	11.2
13	12.6	12.6	12.6	11.8	12.6	12.4	12.4	10.8	12.0	11.6	9.5	10.8
14	12.6	13.6	11.4	11.0	11.0	13.0	11.4	12.6	12.0	10.8	10.2	10.0
15	13.0	13.4	11.4	9.6	11.2	12.2	12.2	9.2	9.2	9.4	—	—
16	13.8	12.8	9.2	9.8	11.4	11.6	11.6	10.8	8.0	8.8	—	—
17	12.4	12.4	9.6	12.4	11.2	12.4	12.0	12.2	8.4	8.0	—	—
18	12.6	12.6	10.0	10.0	10.8	11.6	12.0	12.2	8.4	8.0	—	—
19	12.4	11.6	—	—	11.4	12.4	9.6	9.2	—	—	—	—
20	10.4	10.8	—	—	—	—	8.8	9.6	—	—	—	—
21	8.8	9.0	—	—	—	—	—	9.6	—	—	—	—
Average...	12.3	12.4	11.4	11.2	12.9	11.9	10.7	10.6	10.9%	10.4	11.6	11.3
Av. of av...	12.35		11.3		11.9		10.65		10.5		11.45	

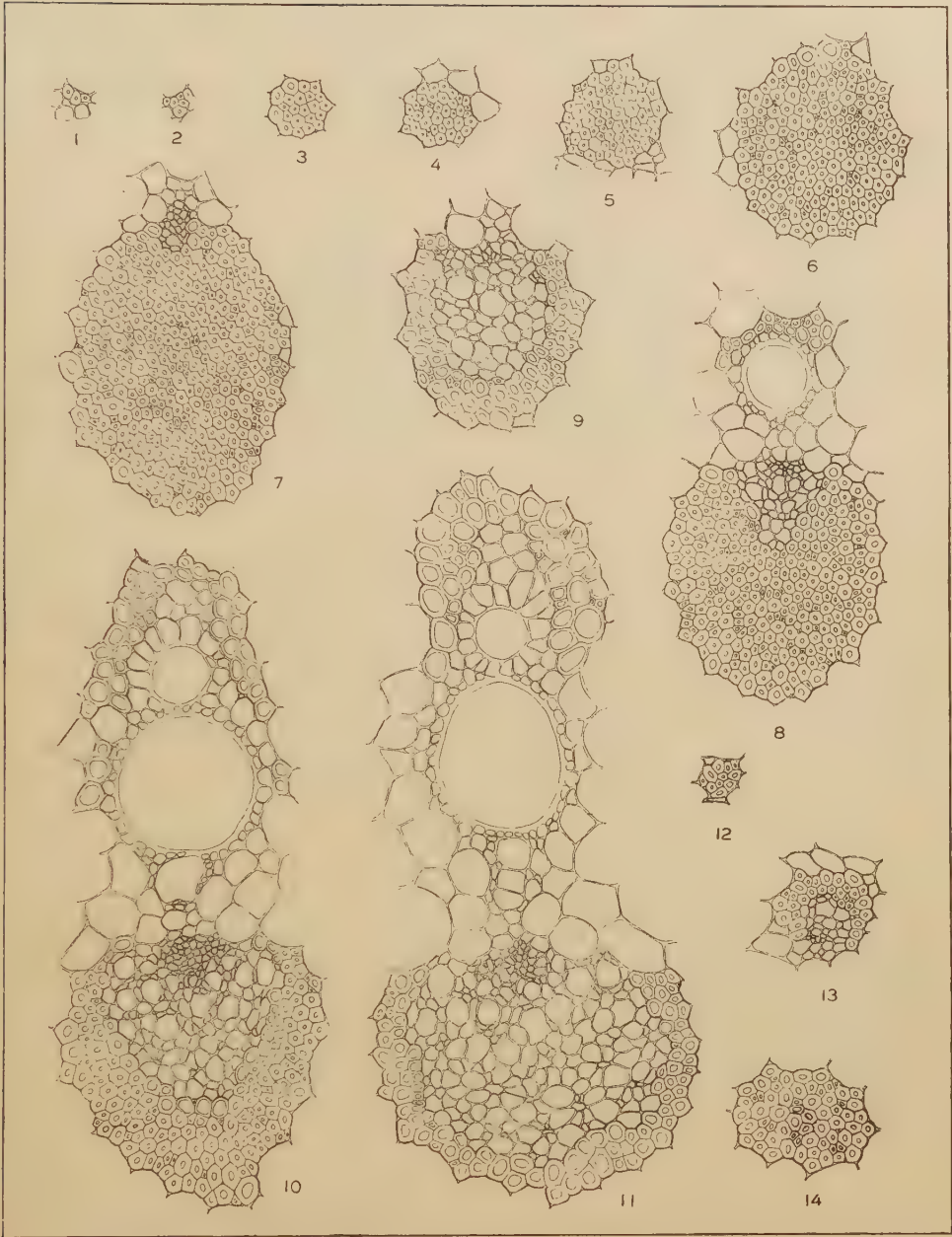


PLATE I

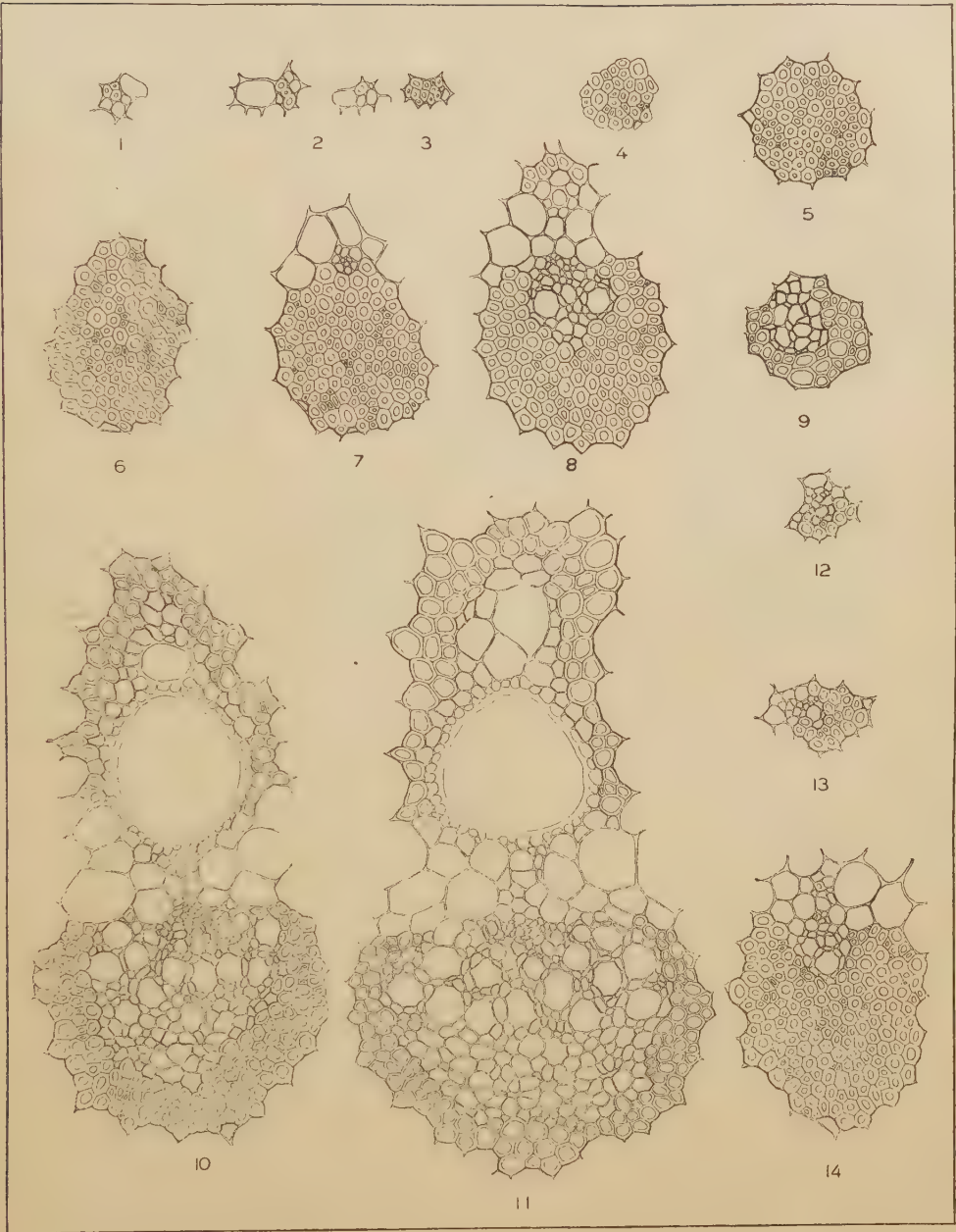


PLATE II

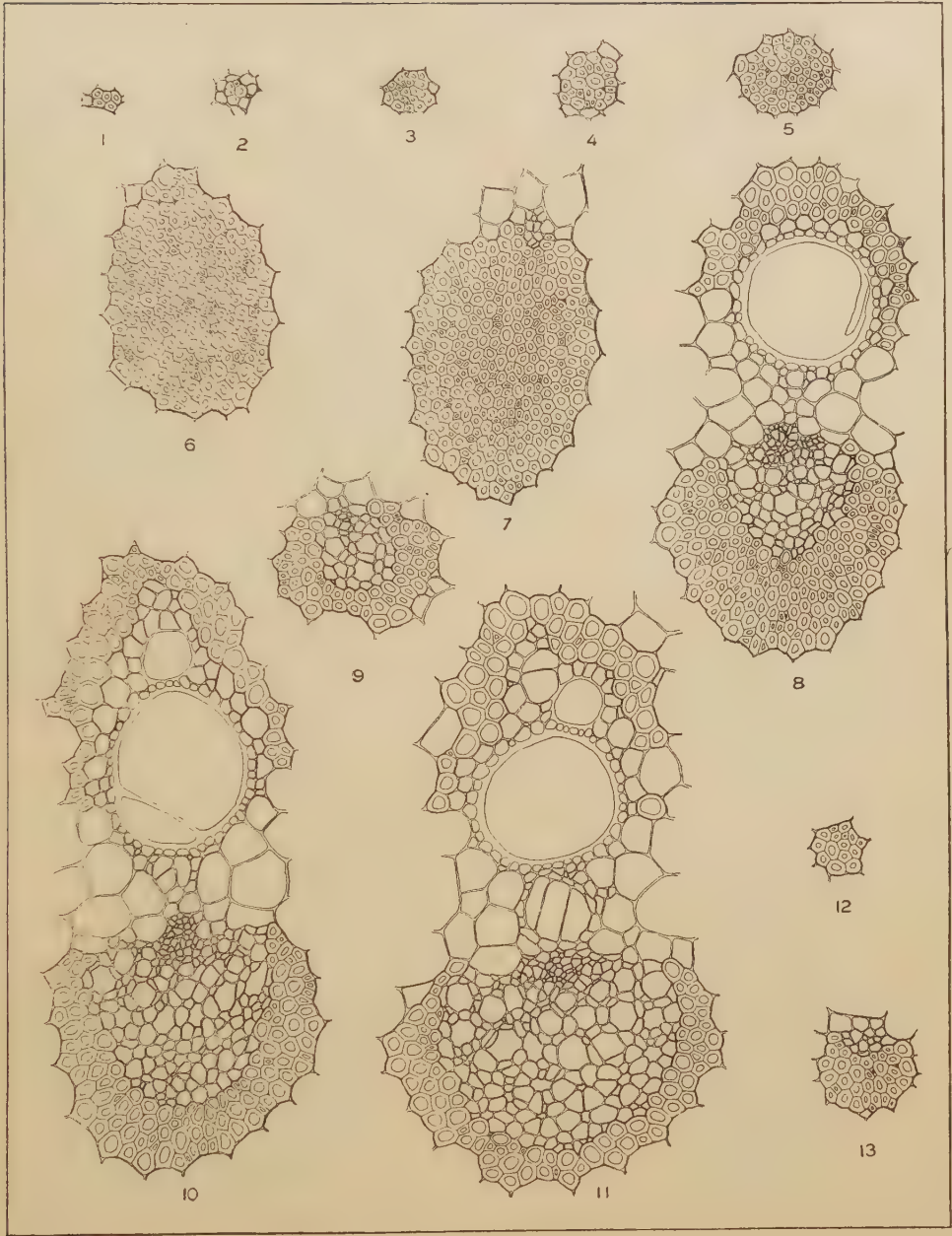


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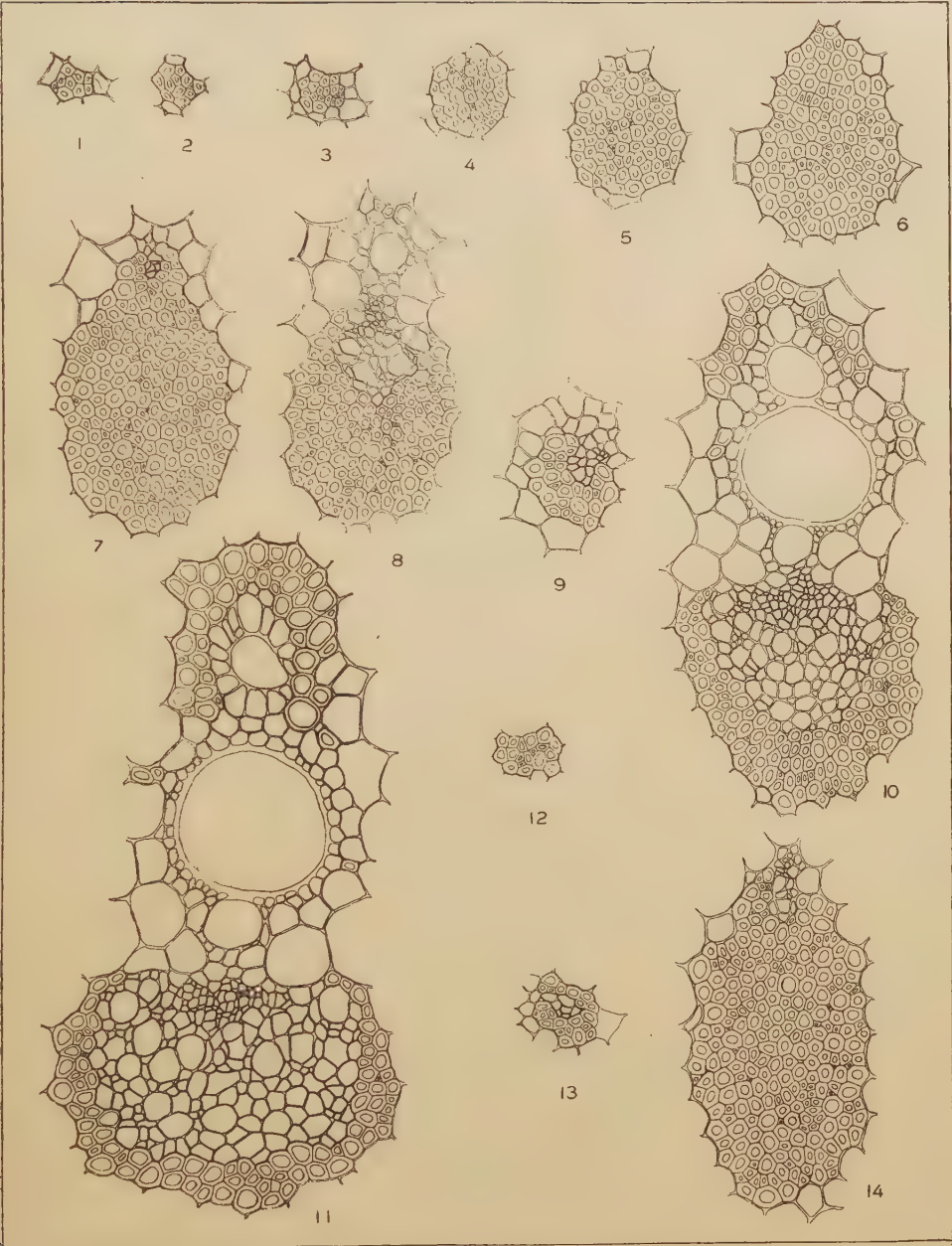


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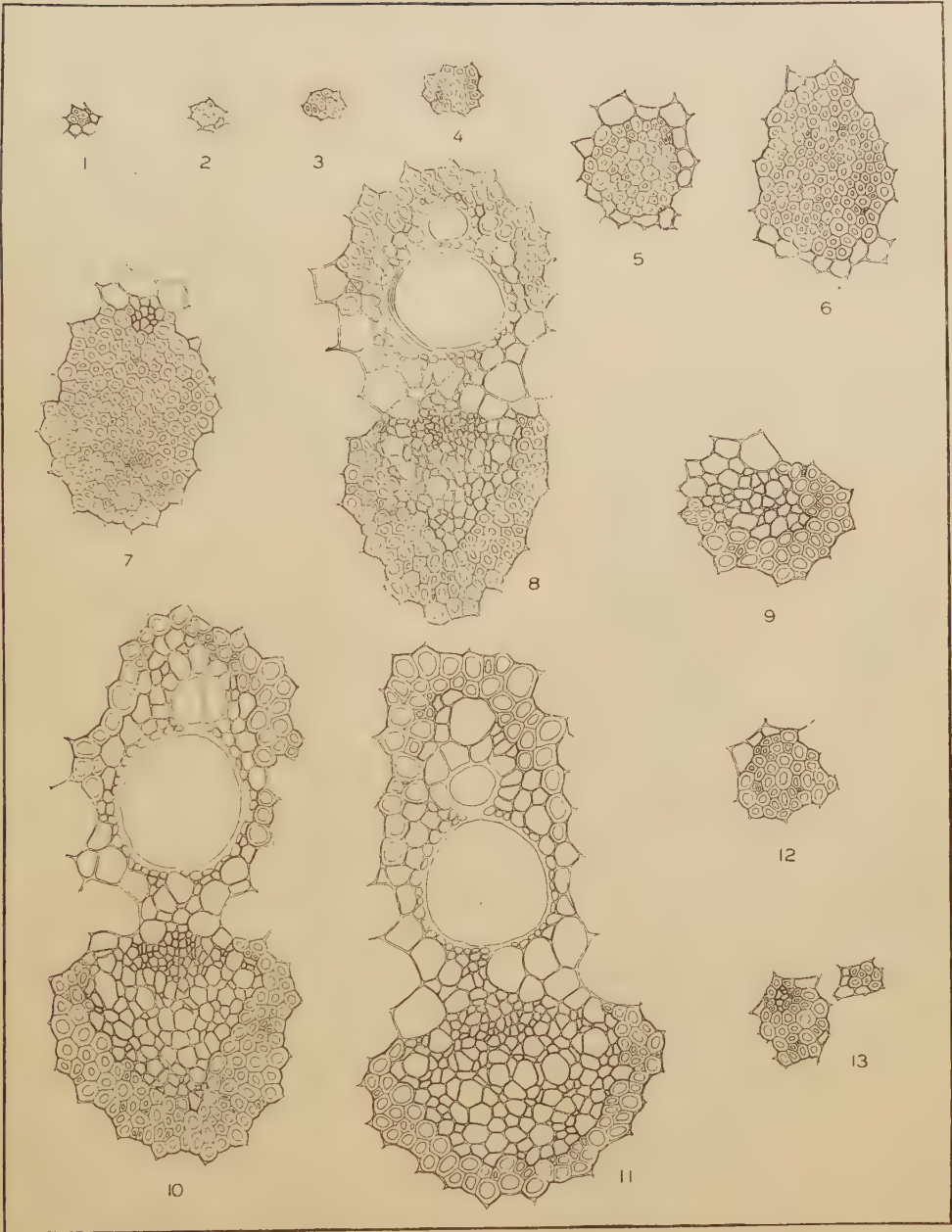


PLATE V

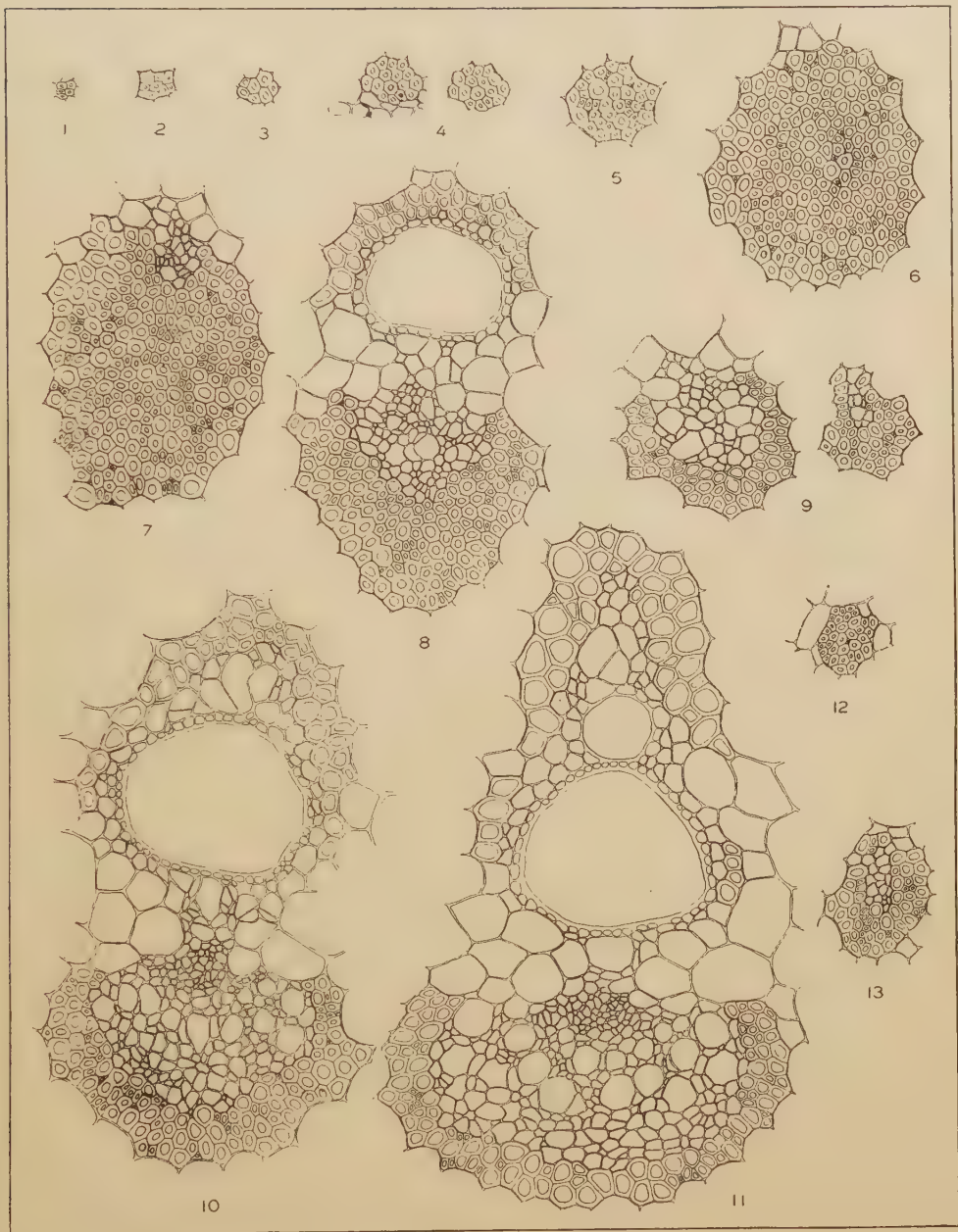


PLATE VI

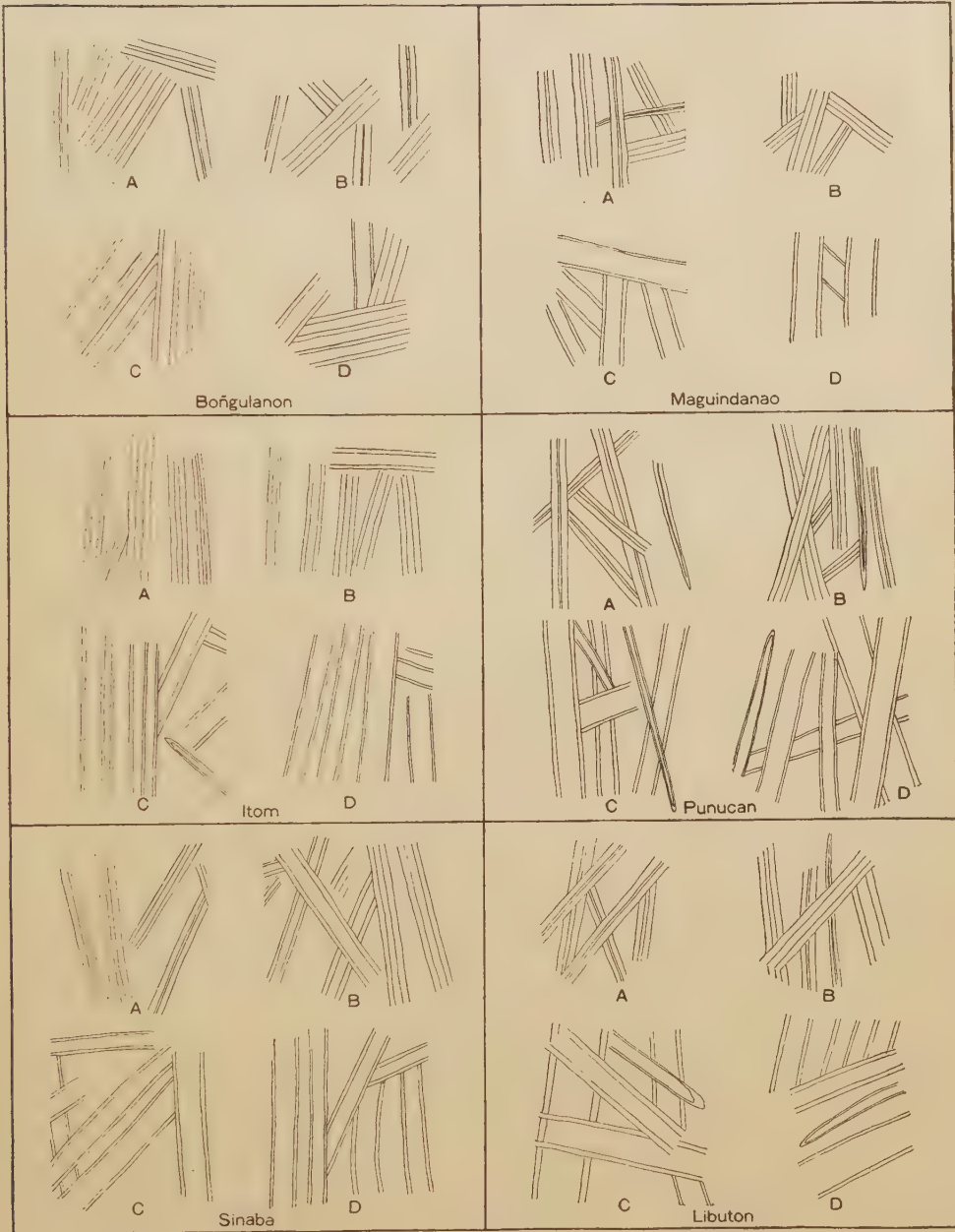


PLATE VII

COMPARATIVE STUDY OF FIBERS PRODUCED BY SIX VARIETIES OF ABACA WHEN GROWN IN LOS BAÑOS: II.¹

By R. B. ESPINO and JOSÉ CHICO REYES

WITH SEVEN PLATES

This paper deals with the character and qualities of the fibers obtained from six varieties of abaca and is a continuation of a similar investigation started by Espino and Esguerra (1) in 1922, thereby completing the work on twelve varieties. This study was made during the college year 1922-23, and was carried out at the College of Agriculture, Los Baños.

MATERIALS, METHODS AND RESULTS

VARIETIES USED

The varieties used in this study were Pinoonan, Samoro puti, Agogaron, Ilayas, Bulao, and Kalado. These varieties are grown side by side at the College of Agriculture and so are under the same soil and climatic conditions. The first two varieties were described by Vista as follows:

a. Musa textilis Née. Var. *Kalado* (C. A. 4292).—Produces 6-15 sprouts to a hill but 2-5 are medium, and 3-8 small, crowded in the hill; very fast growers and erect. False stem is 2.30-2.65 meters high, 15-17 centimeters diameter at enlarged base and 9-12 centimeters diameter at top.

This variety was collected from Leyte and introduced into the College from the Bureau of Agriculture in December, 1915. The fibers are short and weak.

b. Musa textilis Née. Var. *Pinoonan* (C. A. 9281).—Produces about 9-10 sprouts to a hill but 2-5 are small, crowded in the hill, fast grower, slanting and poor stooler. False stem is 3.81 meters average height, 12-21 centimeters diameter at enlarged base and 7-11 centimeters diameter at top. Outer leaf-sheath green-blotched with modder brown in regular order.

This variety was collected from Barauen, Leyte, on June 6, 1919, by Mr. Lipayan.

The other four varieties as seen in the nursery may be described as follows:

c. Musa textilis Née. Var. *Ilayas* (C. A. 10287).

Produces about 6-17 sprouts to a hill but 2-6 are small, crowded in the hill, fast grower, poor stooler. False stem is about 3.85 meters high, 22-25 centimeters diameter at enlarged base and 10-13 centimeters diameter at top.

This variety was introduced into the College from the Bureau of Agriculture on October 9, 1918.

d. Musa textilis Née. Var. *Samoro puti* (C. A. 4279).

Produces about 8-26 sprouts to a hill but the stalks are small and slender, crowded in the hill. False stem is 2-2.74 meters high, 12-14 centimeters diameter at enlarged base and 6-7 centimeters diameter at top.

This variety was introduced into the College from Lamao Experiment Station on September 7, 1918.

e. Musa textilis Née. Var. *Bulao* (C. A. 169).

Produces about 4-15 sprouts to a hill, not crowded, uniform but low. False stem about 2.92 meters high and about 21 centimeters diameter at enlarged base and about 12.5 centimeters diameter at top.

This variety was introduced into the College from the Bureau of Agriculture on October 9, 1918.

f. Musa textilis Née. Var. *Agogaron* (C. A. 9533).

¹ Thesis presented for graduation from the College of Agriculture, No. 157; Experiment Station contribution No. 129.

Produces about 17 sprouts to a hill, five of which are big and twelve are small, not crowded, slanting, uniform. False stem is 2.5-2.8 meters high, 18-19 centimeters diameter at enlarged base and 9-10 centimeters diameter at top.

This variety was introduced into the College from Oas, Albay, on November 19, 1918.

MICROSCOPIC STUDY

From the outermost leaf-sheath of each of the varieties studied, microtome sections were prepared. These were taken from the middle and from portions two centimeters away from either edge, and one-half meter above the ground. The different types of fiber found in each specimen were drawn under a compound microscope with the aid of a camera lucida. The drawings are shown in Plates I-VI.

To separate the fiber cells, samples of fibers from the edges and from the middle of the outermost leaf-sheath of each variety were macerated, and representative cells drawn (see Plate VII). The dimensions of these cells were taken and the data obtained are shown (in average) in Table I.

CROSS-SECTIONAL AREA

The cross-sectional area of each of the fiber strands drawn in Plates I to VI and obtained from the different varieties studied was determined with the use of a planimeter. The data are given in Table II. In this table may be seen averages of measurements made by Espino and Esguerra (1) with the fibers of six varieties of abaca.

TENSILE STRENGTH OF FIBERS

The fibers from the edges and middle of each leaf-sheath were extracted separately. The fibers obtained were dried in the air and samples composed of five fibers of average size, 50 centimeters in length were prepared. The strength of these samples was determined with the use of the apparatus employed by Espino and Esguerra.

The relative values of the actual breaking weights (or tensile strength) are given in Table III. Table IV shows the relative values of the calculated tensile strength of fiber in terms of a gram weight of the sample.

BREAKING STRETCH

The relative stretching power of the different samples of fiber studied was measured at the time when each sample employed in the tensile strength tests broke. The average measurements are given in Table V.

DISCUSSION OF RESULTS

THE FIBER-CELLS

The length.—The data on dimensions of fiber-cells are summarized in Table I. Examination of this table will show that the fiber-cells from the edges of each leaf-sheath were shorter than those from the *middle*. The fibers from the *edges* of the leaf-sheath of Ilayas, Boñgulanon and Itom had comparatively long fiber-cells, being about 6.5898 millimeters for Ilayas. The shortest fiber-cells were from Agogaron, 2.4433 millimeters. Punucan and Bulac also had short fiber-cells from the *edges* of a leaf-sheath. The fibers of the other varieties studied not mentioned here may be considered of medium length.

Gross diameter.—As a rule the fiber-cells from the *middle* of a leaf-sheath were wider than those from the *edges*. The widest cells were from Kalado,

0.02231 millimeter. The other varieties that had wide cells were Samoro-puti, Pinoonan and Boñgulanon. The narrowest were from Agogaron, 0.01373 millimeter, closely followed by Sinaba and Punucan.

Thickness of walls.—As shown in Table I the walls of the fiber-cells from the *edges* were thicker than those from the *middle*. However, this was not true in the case of Agogaron, in which the walls of the fiber-cells obtained from the *middle* portion were thicker than those from the *edges* of the same leaf-sheath. As illustrated in Figure 1, Boñgulanon had the thickest walls. The other varieties that had relatively thick walls were Kalado, Maguindanao, Pinoonan and Libuton. The thinnest walls was exhibited by Bulao. Samoro-puti and Agogaron had also relatively thin walls. The rest of the varieties had walls which may be considered of relatively medium thickness.

Diameter of lumen.—In all cases the lumina of the fiber-cells from the *midrib* were wider than those from the *edges*. The averages for the fibers from the *edges* show that the Kalado, Samoro-puti, Pinoonan and Boñgulanon had relatively wide lumina. Agogaron, Sinaba and Punucan had narrow lumina.

THE FIBER STRANDS

Cross-sectional area.—The measurements of the cross sectional areas of the different fiber strands showed a variation ranging from 0.00036 to 0.06148 square millimeter. The first six strands as shown in Table II are purely sclerenchymatous cells. Fiber No. 7 has very little conducting tissues and as reported by Espino (2) are the largest solid fibers obtained in stripping.

The largest cross-sectional area was from the fiber of the variety Agogaron, but Espino and Esguerra found two other varieties (Boñgulanon and Sinaba) which yielded fibers still coarser than Agogaron. Of the twelve varieties so far studied and in the order of size from the coarsest to the finest (total for the 13 strands) of usually extractable fiber strands as shown in Plates I to VI, Boñgulanon was the coarsest, followed by Sinaba, Agogaron, Libuton, Ilayas, Kalado, Samoro-puti, Maguindanao, Panucan, Itom, Pinoonan, and Bulac. Of these varieties that had coarse fibers were the Boñgulanon, Sinaba and Agogaron. Relatively fine fibers were obtained from Bulao, Pinoonan and Itom (fig. 1).

Appearance in cross-section.—It will be seen in Plates I to VI that figures under F and H are purely sclerenchymatous strands. These fibers together with those shown in figures under E and I make up the bulk of the fibers found in the market. The fiber strands from the "bridge" and in the inner portions of a leaf-sheath are usually not included in the "tuxies". They are thrown away with the "waste" in stripping. Each of these vascular bundles has but one or two layers of sclerenchymatous cells. The main bulk of the constituent cells are vessels and other conducting elements.

Tensile strength.—The actual as well as the calculated tensile strength (see Tables III and IV, respectively) were greatest with fibers obtained from the leaf-sheaths somewhere between the outermost and innermost sheaths of a trunk. A similar result obtained by Espino and Esguerra from six varieties of abaca and also by Espino who advanced an explanation that the comparative weakness of the fiber from the outer leaf-sheath is due to the presence of strings of silica, or stigmata, which in turn is responsible for the brittleness of the fiber. Espino

believed that the comparatively low tensile strength of the fiber from a group of innermost leaf-sheaths is probably due to immature stage of the fiber; the walls are not yet fully developed.

The tensile strength of the fibers from the *edge* of leaf-sheaths of twelve varieties so far studied show that in terms of the breaking weight of the samples of 5 fibers each, 50 centimeters long, the fiber of Boñgulanon was the strongest; followed in strength by Sinaba, Libuton, Maguindanao, Punucan and Itom.

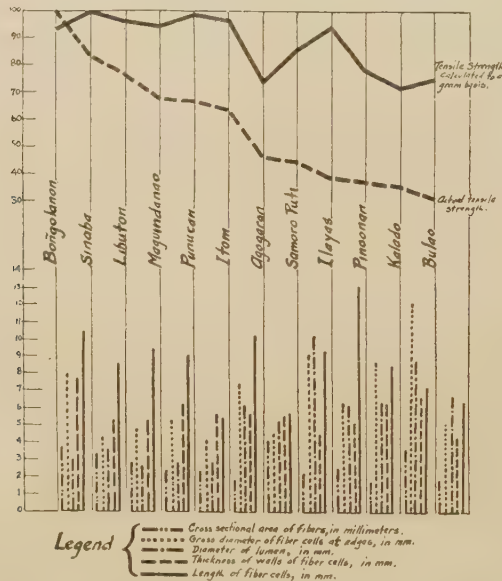


Fig. 1. Comparative tensile strength (average) of the fibers from the edges of the leaf-sheaths of 12 varieties of abaca including dimensions of cells.

(See Tables II and III and Fig. 1.) Under this criterion the weakest was Bulao. Kalado, Pinoona and Ilayas may also be considered as weak. But in terms of a given weight of the samples (see fig 1), the strongest was Sinaba, followed in a descending order by Punucan, Itom and Libuton. Relatively weak fibers were produced by Kalado, Agogaron, Bulao and Pinoonan. The other varieties not mentioned produced fibers which may be considered of medium or relatively moderate tensile strength.

As shown in Figure 1 an attempt was made to correlate the strength of the fibers of the different varieties with their respective physical characteristics. It appears that although in some varieties a large cross-sectional area of the fiber was accompanied by a high strength, yet the data on hand make it impossible to advance such a generalization for the twelve varieties so far studied. An increase in the thickness of the walls was not always accompanied by a proportionally increase in the tensile strength of the fiber. Kalado and Pinoonan, although both have relatively thick walls, the strength of the fibers were relatively low. It is suggested that irrespective of the thickness cell-walls, the area of the fiber, or of any of the known qualities of the fiber and of the fiber-element, the fibers of the different varieties may naturally and peculiarly be strong or weak.

Breaking stretch.—The data on the *breaking stretch* of the fibers from the varieties just studied together with those studied by Espino and Esguerra showed that in almost all cases the fibers from the *midrib* had a greater breaking stretch than the corresponding fiber from the *edges* of each leaf-sheath of the same variety. The difference, however, was very small. In the majority of cases the breaking stretch was proportional to the load that was sustained by the fiber. In other words the tensile strength was usually accompanied by a corresponding high stretching power of the fiber.

SUMMARY AND CONCLUSIONS

1. The fiber-cells from the edges of the leaf-sheath of Ilayas, Boñgulanon, and Itom were comparatively long while Agogaron had the shortest. Punucan and Bulao had also short fiber-cells and the rest were of medium length.

2. Kalado had the widest fiber-cells, this being 0.0223 millimeter. Samoro-puti, Pinoonan and Boñgulanon had also wide cells. The narrowest (0.01373 mm.) were from Agogaron. Sinaba and Punucan may also be considered to have narrow fiber-cells.

3. Boñgulanon had the thickest cell wall followed in thickness by Kalado, Maguindanao, Pinoonan and Libuton. Bulao had the thinnest. Samoro-puti and Agogaron had also thin walls. The rest had walls of medium thickness.

4. Kalado, Samoro-puti, Pinoonan and Boñgulanon had relatively wide lumina. The lumina of the fiber elements of Agogaron, Sinaba and Punucan were narrow.

5. The varieties Boñgulanon, Sinaba and Agogaron produced coarse fibers; while the fibers obtained from Bulao, Itom and Pinoonan were relatively fine.

6. Comparatively short fibers were obtained from the leaf-sheaths somewhere between the outermost and innermost leaf-sheaths in a trunk of abaca. In terms of the number of filaments Bongulanon had the strongest fibers followed in strength, in a descending order by Sinaba, Libuton, Maguindanao, Punucan and Itom. The weakest fibers were from Bulao. Kalado, Pinoonan, and Ilayas also had relatively weak fibers. But in terms of a given weight of the sample the strongest was Sinaba. Punucan, Itom and Libuton also had strong fibers. Agogaron, Bulao and Pinoonan produced relatively weak fibers. The others may be considered of medium strength.

7. Although in some way coarseness of the fibers and thickness of the cell-walls are largely responsible for the strength of the fibers, yet the data on hand seem to show that fibers of certain varieties are naturally either strong or weak, irrespective of these qualities.

8. A high tensile strength was usually accompanied by a corresponding high stretching power of the fibers.

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ILLUSTRATIONS

PLATE I

ABACA VAR. PINOONAN

From the midrib:

- A. Figure 4—Fiber strand with purely sclerenchymatous cells, near inner epidermis.
- B. Figures 1-3 small vascular bundles, near inner epidermis.
- C. Figures 5 and 6 big vascular bundles at the "bridge".
- D. Figures 12 and 16 big vascular bundles near the "bridge".
- E. Figures 7 and 8 fiber strands with little conducting tissues near outer epidermis.
- F. Figures 9-11 and 13-15 fiber strands with purely sclerenchymatous cells, near outer epidermis.

From the edge:

- G. Figures 17-22 fiber strands with purely sclerenchymatous cells.
- H. Figures 23 and 24 fiber strands with little conducting tissues.
- I. Figure 25 big vascular bundle.

PLATE II

ABACA VAR. SAMORO PUTI

From the midrib:

- A. Figure . . —Fiber strand with purely sclerenchymatous cells, near inner epidermis.
- B. Figures 1-4 small vascular bundles near inner epidermis.
- C. Figures 5 and 6 big vascular bundles at the "bridge".
- D. Figures 13 and 15 big vascular bundles near the "bridge".
- E. Figure 8 fiber strand with little conducting tissue, near outer epidermis.
- F. Figures 7, 9-14 fiber strands with purely sclerenchymatous cells, near outer epidermis.

From the edge:

- G. Figures 16, 19, 21 and 22 fiber strands with purely sclerenchymatous cells.
- H. Figures 20, 23 and 24 fiber strands with little conducting tissues.
- I. Figure 25 big vascular bundle.

PLATE III

ABACA VAR. AGOGARON

From the midrib:

- A. Figures 2 and 3 fiber strands with purely sclerenchymatous cells, near inner epidermis.
- B. Figures 1 and 4 small vascular bundles near inner epidermis.
- C. Figures 5 and 6 big vascular bundles at the "bridge".
- D. Figures 13 and 16 big vascular bundles near the "bridge".
- E. Figures 7 and 8 fiber strands with little conducting tissues, near outer epidermis.
- F. Figures 9-15 fiber strands with purely sclerenchymatous cells, near outer epidermis.
- G. Figures 18, 20-22 and 24 fiber strands with purely sclerenchymatous cells.
- H. Figures 17, 19, 23 and 25 fiber strands with little conducting tissues.
- I. Figure 26 big vascular bundle.

PLATE IV

ABACA VAR. ILAYAS

- A. Figure 23 fiber strand with purely sclerenchymatous cells, near inner epidermis.
- B. Figures 20 and 21 small vascular bundles, near inner epidermis.
- C. Figure 22 big vascular bundle at the "bridge".
- D. Figures 16, 19 and 24 big vascular bundle near the "bridge".
- E. Figure 12 fiber strands with little conducting tissues, near outer epidermis.
- F. Figures 11, 13-15, 17 and 18 fiber strands with purely sclerenchymatous cells, near outer epidermis.

From the edge:

- G. Figures 1, 4, 5, and 7-9 fiber strands with purely sclerenchymatous cells.
- H. Figures 2 and 3 fiber strands with little conducting tissues.
- I. Figures 6 and 10 big vascular bundles.

PLATE V

ABACA VAR. BULAO

From the midrib:

- A. Figure 3.—Fiber strand with purely sclerenchymatous cells, near inner epidermis.
- B. Figures 1 and 2 small vascular bundles near inner epidermis.
- C. Figure 4 big vascular bundle at the "bridge".
- D. Figures 6 and 8 fiber strands with little conducting tissues, near outer epidermis.
- E. Figures 7, 9-12 and 14 fiber strand with purely sclerenchymatous cells, near outer epidermis.

From the edge:

- F. Figures 16-19, 21 and 22 fiber strands with little purely sclerenchymatous cells.
- G. Figures 20-24 fiber strands with little conducting tissue.
- H. Figure 25 big vascular bundle.

PLATE VI

ABACA VAR. KALADO

From the midrib:

- A. Figures 1 and 4 fiber strands with purely sclerenchymatous cells near inner epidermis.
- B. Figures 2 and 3 small vascular bundles near inner epidermis.
- C. Figure 5 big vascular bundle at the "bridge".
- D. Figures 6, 15 and 18 big vascular bundles near the "bridge".
- E. Figures 9 and 11 fiber strands with little conducting tissues, near outer epidermis.
- F. Figures 7, 8, 10, 12, 13-17 fiber strands with purely sclerenchymatous cells near the outer epidermis.

From the edge:

- G. Figures 19, 22, 23, 25-27 fiber strands with purely sclerenchymatous cells.
- H. Figures 20 and 21 fiber strands with little conducting tissues.
- I. Figures 24 and 28 big vascular bundles.

PLATE VII

FIBER CELLS OF SIX VARIETIES OF ABACA

- Figures 1 and 2, fiber cells from the edge and midrib, respectively, of variety Agogaron.
Figures 3 and 4, fiber cells from the edge and midrib, respectively, of variety Ilayas.
Figures 5 and 6, fiber cells from the edge and midrib, respectively, of variety Pinoonan.
Figures 7 and 8, fiber cells from the edge and midrib, respectively, of variety Bulao.
Figures 9 and 10, fiber cells from the edge and midrib, respectively, of variety Kalado.
Figures 11 and 12, fiber cells from the edge and midrib, respectively, of variety Samoro puti.

TABLE I.—Average dimensions of fiber-cells.

Origin of fiber-cell.	Variety name.	Dimensions of fiber-cells.			
		Gross diam-eter.	Diameter of lumen.	Thickness of wall.	Length.
From edges of leaf-sheath		<i>mm.</i>	<i>mm.</i>	<i>mm.</i>	<i>mm.</i>
	Pinoonan.....	.01895	.00644	.00640	4.4789
	Samoro puti.....	.01915	.01041	.00437	4.6409
	Agogaron.....	.01373	.00445	.00464	2.4433
	Ilayas.....	.01646	.00624	.00511	6.5898
	Bulao.....	.01537	.00679	.00433	3.1179
	Kalado.....	.02231	.00889	.00683	3.7024
From middle of leaf-sheath	Pinoonan.....	.01985	.01143	.00421	6.3093
	Samoro puti.....	.02215	.01490	.00367	5.5477
	Agogaron.....	.01880	.00835	.00542	3.8610
	Ilayas.....	.02040	.01229	.00410	7.5701
	Bulao.....	.02079	.01326	.00402	4.0447
	Kalado.....	.02313	.01431	.00441	4.3620
Edges and middle (averages)	Pinoonan.....	.01940	.00894	.00532	5.3941
	Agogaron.....	.01627	.00640	.00503	3.1522
	Ilayas.....	.01843	.00927	.00461	7.0800
	Bulao.....	.01808	.01003	.00418	3.5813
	Kalado.....	.02272	.01160	.00562	4.0322

TABLE II.—Cross-sectional area of sclerenchyma strands obtained from different parts of a sheath of each of six varieties of abaca.

Strand No.	From edges.						From middle.					
	Pinoonan.	Samoro puti.	Agogaron.	Ilayas.	Bulao.	Kalado.	Pinoonan.	Samoro puti.	Agogaron.	Ilayas.	Bulao.	Kalado.
1	sq. mm. .00071	sq. mm. .00068	sq. mm. .00071	sq. mm. .00036	sq. mm. .00048	sq. mm. .00095	sq. mm. .00101	sq. mm. .00074	sq. mm. .00068	sq. mm. .00053	sq. mm. .00068	sq. mm. .00042
2	.00083	.00125	.00151	.00889	.00143	.00149	.00143	.00178	.00101	.00662	.00178	.00143
3	.00318	.00291	.00281	.00232	.00193	.00193	.00291	.00261	.00211	.00258	.00303	.00309
4	.00956	.00385	.00591	.00478	.00428	.00508	.00460	.00398	.00309	.00891	.00422	.00400
5	.01072	.01342	.01203	.01016	.00787	.01054	.00460	.00933	.00787	.01880	.00817	.00817
6	.02082	.01696	.03267	.02822	.01408	.02896	.01910	.02471	.02747	.02928	.01559	.02349
7	.03053	.03718	.04514	.03858	.03124	.04517	.04458	.04505	.05192	.04915	.03647	.03816
8	.03686	.04069	.06038	.04253	.03080	.04814						
9	.00582	.00600	.01758	.01197	.01114	.01143						
10	.02328	.02964	.05192	.04823	.01669	.03828						
11	.03460	.04782	.05842	.03867	.04666	.06148						
12	.00244	.00502	.00647	.00526	.00395	.00481						
13	.00214	.00662	.00846	.00469	.00309	.00633						
Total from 1 to 7 incl.	.07635	.07825	.10078	.08531	.06131	.09412	.08091	.08820	.09415	.10987	.06994	.07966
Total from 8 to 13 incl.	.10514	.13579	.20323	.15135	.11233	.17047						
Total	.18149	.21404	.30401	.23666	.17364	.26459						
Total from 1 to 7 incl.	Bongulanon	Libuton	Maguin-danao	Itom	Sinaba	Punucan						
	.14458	.10554	.09212	.04903	.12689	.07534						
Total from 8 to 13 incl.	.22093	.18084	.11918	.14715	.19980	.13535						
Total	.36551	.28638	.21130	.19618	.32669	.21069						

TABLE III.—*Relative values of the actual breaking weights (or tensile strength). a*

Leaf-sheath No.	Data from the present study.						Data from Espino and Esguerra.					
	Pino-onan.	Sa-moro-puti.	Agoga-ron.	Ilayas.	Bulao.	Kala-do.	Bo-ngula-non.	Itom.	Libu-ton.	Ma-guin-danao.	Punu-can.	Si-na-ba.
1	29	30	31	32	27	24	75	48	56	44	50	66
2	35	29	36	29	24	26	74	56	62	46	50	69
3	28	22	35	31	24	29	74	59	66	49	57	71
4	35	32	46	40	23	26	72	45	75	50	58	74
5	30	37	45	36	27	29	83	67	60	53	61	74
6	29	34	42	32	21	26	79	61	69	61	64	78
7	27	31	41	35	25	31	83	69	74	65	60	68
8	33	39	38	31	25	28	86	57	77	72	63	70
9	30	33	42	35	27	29	99	67	67	78	55	64
10	35	40	43	31	21	27	100	59	61	73	51	56
11	25	38	41	28	25	23	78	56	60	54	52	45
12	21	38	40	32	22	23	89	51	66	48	47	41
13	22	38	37	26	20	21	80	43	64	54	43	43
14	21	40	24	23	20	22	80	36	56	49	44	28
15	20	32	20	20	20	15	70	30	48	43	42	
16	14	29	21	18	20	17	67	22	32	38	28	
17		25	18	17	17		56	20	32	35	18	
18			14	11			56	19	36	31		
19				12			48		26	25		
20							54			26		
21							25					
Min.....	14	22	14	11	17	15	25	19	26	25	18	28
Max.....	35	40	46	40	27	31	100	69	77	78	64	78
Av. a....	27.1	33.4	34.1	27.3	22.8	24.8	72.8	48.1	57.2	49.7	49.6	60.5
Relative value of average	37	46	47	38	31	34	100	66	76	69	68	83

a The highest record of the actual breaking weight was considered as 100; the others were reduced relatively.

TABLE IV.—*Relative values of the calculated tensile strength of fiber in terms of a gram weight of the sample.*

Leaf-sheath No.	Data from the present study.						Data from Espino and Esguerra (1).					
	Pino-onan.	Sa-moro-puti.	Agoga-ron.	Ilayas.	Bulao.	Kala-do.	Bo-ngula-non.	Itom.	Libu-ton.	Ma-guin-danao.	Punu-can.	Si-na-ba.
1	60	65	48	61	54	39	66	71	61	70	71	66
2	67	59	57	63	57	48	85	87	60	72	75	70
3	59	60	49	56	61	50	72	72	79	75	84	72
4	68	58	68	69	54	63	82	84	76	76	83	73
5	57	64	61	67	60	58	77	80	94	77	82	75
6	68	60	66	71	71	64	81	72	70	77	82	78
7	74	71	62	72	71	63	78	83	74	80	75	87
8	71	67	57	67	69	58	77	74	79	83	81	85
9	68	67	55	71	65	59	79	94	70	83	93	98
10	70	69	53	77	68	55	81	91	76	83	89	91
11	70	80	52	73	66	57	76	88	68	77	82	88
12	58	84	52	73	65	59	77	82	85	77	83	87
13	56	79	64	75	57	63	69	82	81	67	90	94
14	69	80	66	70	62	67	68	79	97	83	100	77
15	65	77	73	82	48	56	71	79	91	77	92	
16	55	76	65	81	51	72	70	68	67	76	64	
17		79	63	76	53		61	90	87	85	53	
18			71	62			54	63	87	68		
19				66			58		90	60		
20							60			67		
21							57					
Min....	55	58	48	56	48	39	54	63	60	60	53	66
Max....	74	84	73	82	71	72	85	94	97	85	100	98
Av. a...	64.7	70.3	60.1	76.1	60.7	58.2	71.4	79.9	78.5	75.7	81.1	81.5
Relative value of average	79	86	74	94	75	71	87	97	96	93	99	100

a The highest record was considered as 100; the rests were computed accordingly.

TABLE V.—Average breaking stretch of fibers from the middle and edges of the different leaf-sheaths from a stalk of six varieties of abaca.

Leaf-sheath No.	Pinoonan.		Samoro puti.		Agogaron.		Ilayas.		Bulao.		Kalado.	
	Middle.	Edge.	Middle.	Edge.	Middle.	Edge.	Middle.	Edge.	Middle.	Edge.	Middle.	Edge.
1	mm. 13.4	mm. 11.4	mm. 10.4	mm. 11.6	mm. 9.4	mm. 7.6	mm. 10.6	mm. 9.6	mm. 11.4	mm. 8.4	mm. 11.2	mm. 8.4
2	18.6	13.2	13.2	10.0	12.8	9.2	10.2	9.6	12.6	10.4	10.8	9.2
3	16.4	12.2	12.0	5.2	13.0	11.8	10.2	9.2	11.0	9.2	11.0	10.6
4	20.8	15.4	11.2	9.2	13.2	11.8	12.6	11.4	11.2	8.6	10.4	13.0
5	16.4	15.0	14.6	9.4	10.6	10.2	12.0	10.8	11.4	8.8	11.2	10.4
6	18.0	11.6	12.2	11.2	14.0	8.2	10.0	9.2	10.8	9.8	9.6	10.2
7	14.0	10.6	12.4	10.2	13.2	12.0	9.6	13.0	11.8	9.4	10.2	9.6
8	14.0	9.4	13.4	11.0	12.8	12.0	9.4	10.6	8.2	7.6	10.6	9.4
9	12.0	9.2	15.4	11.0	15.4	14.0	11.4	11.2	9.8	8.2	10.2	9.0
10	14.8	10.0	14.6	11.8	17.8	13.6	12.0	11.6	9.4	9.4	11.6	9.8
11	12.2	10.2	13.2	10.8	15.2	13.2	10.4	10.2	9.6	10.4	11.0	10.4
12	10.0	11.2	15.2	10.4	12.6	15.4	12.6	10.4	10.0	9.4	10.4	10.6
13	10.8	11.0	14.4	11.2	15.0	13.8	14.4	8.8	10.0	8.6	10.4	9.8
14	12.2	10.0	17.2	12.4	10.8	10.6	11.0	8.3	10.0	9.0	9.8	9.6
15	11.4	8.6	11.2	11.0	11.0	11.2	9.4	9.8	11.2	8.2	8.0	9.4
16	7.6	7.4	12.8	11.0	11.4	10.6	9.2	8.6	9.2	9.0	9.0	10.0
17			12.0	10.2	10.2	8.8	9.4	6.8	9.4	8.6		
18				8.4	8.4	7.4	7.4	7.8				
19						7.4	7.6	7.8				
Average...	13.91	11.03	13.26	10.45	12.60	11.19	10.49	9.72	10.44	9.00	10.34	9.96
Average...	12.47		11.86		11.90		10.11		9.72		10.15	

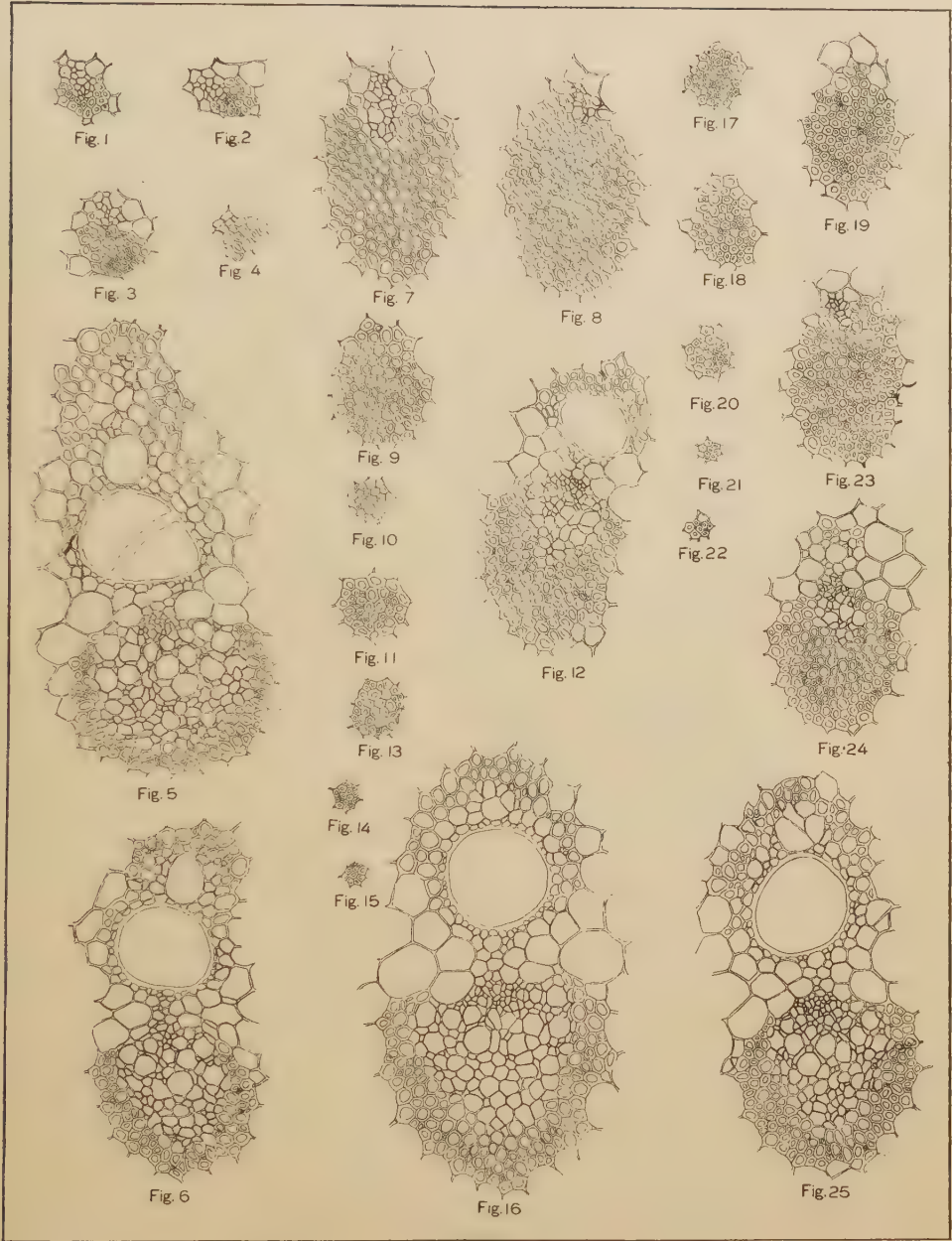


PLATE I

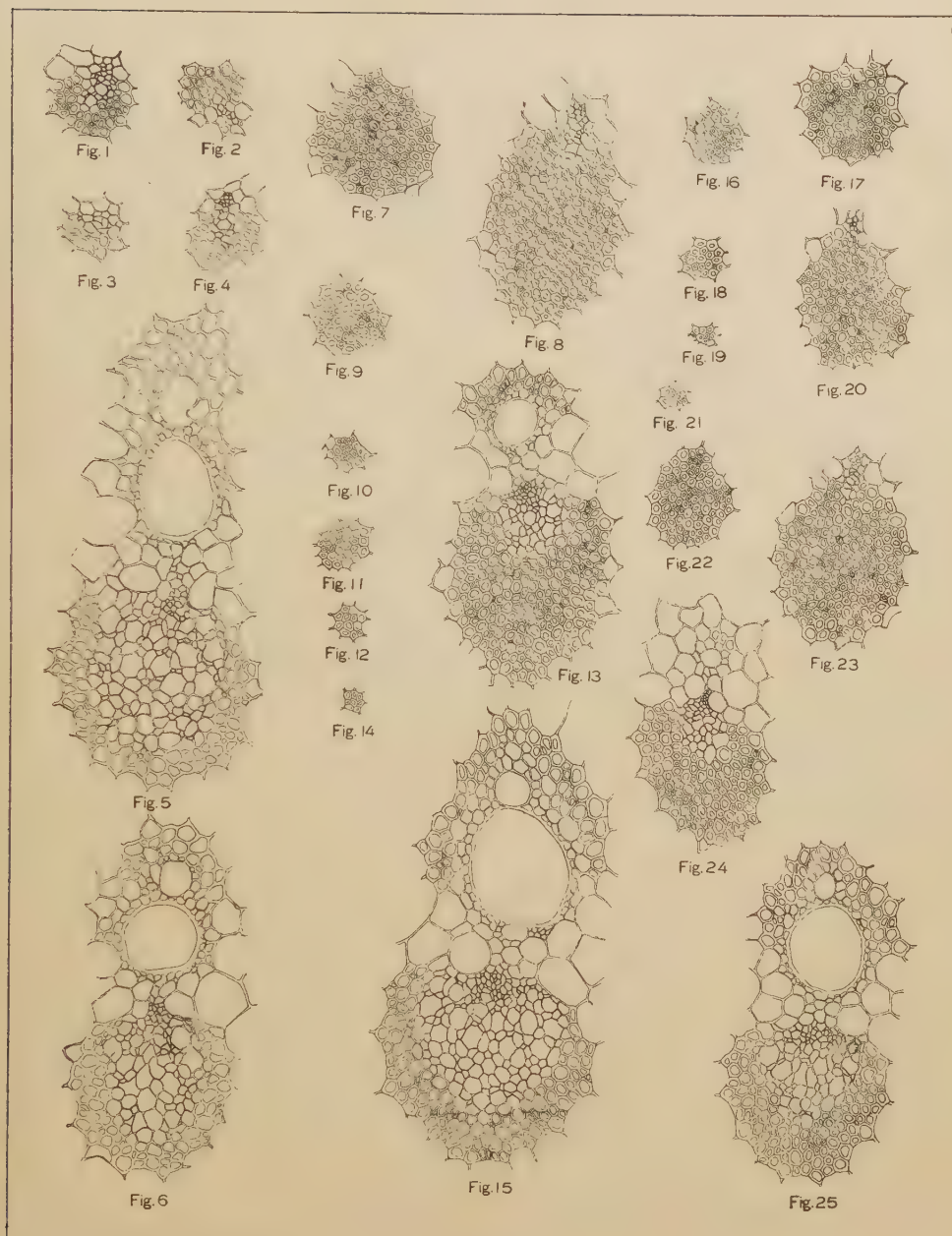


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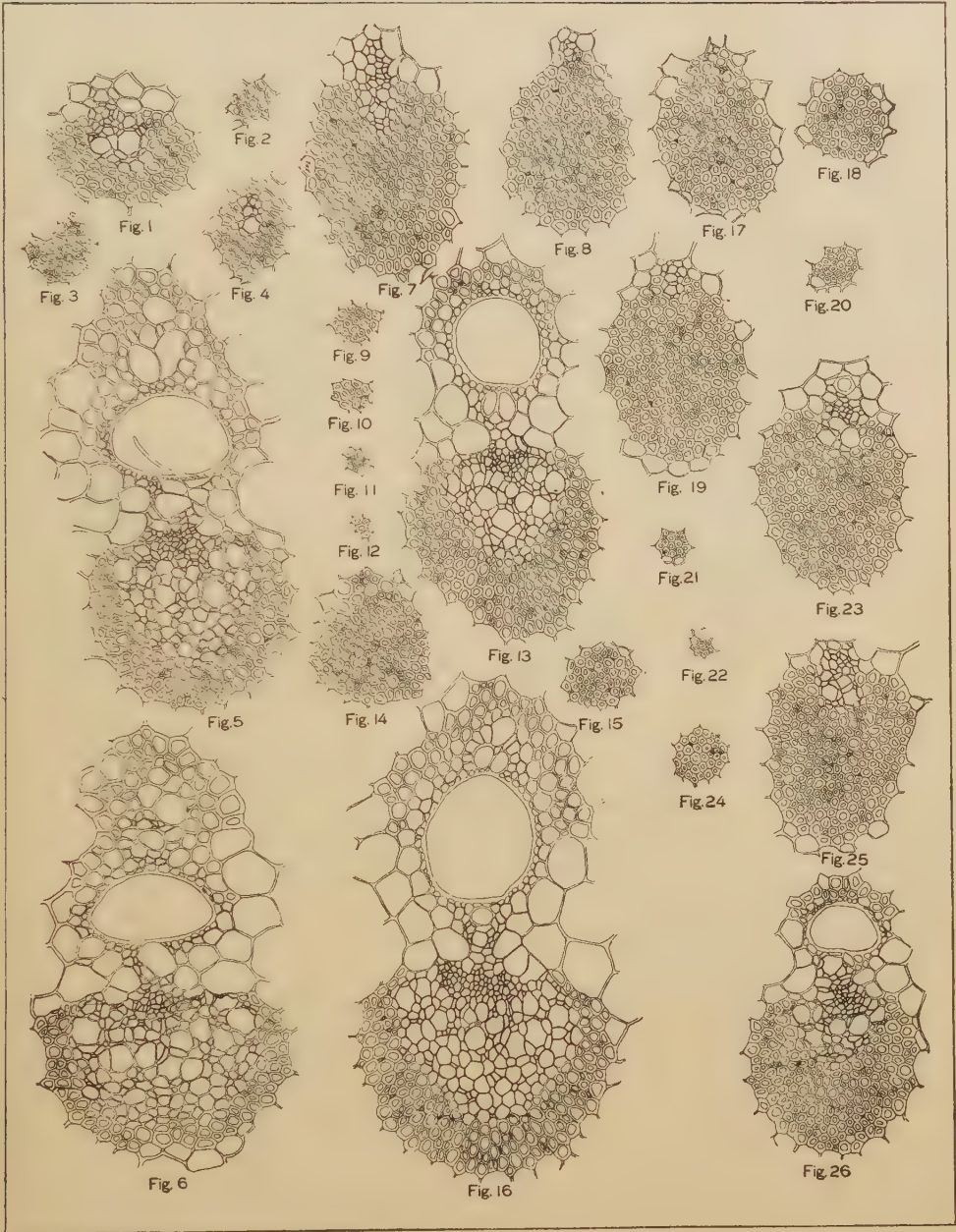


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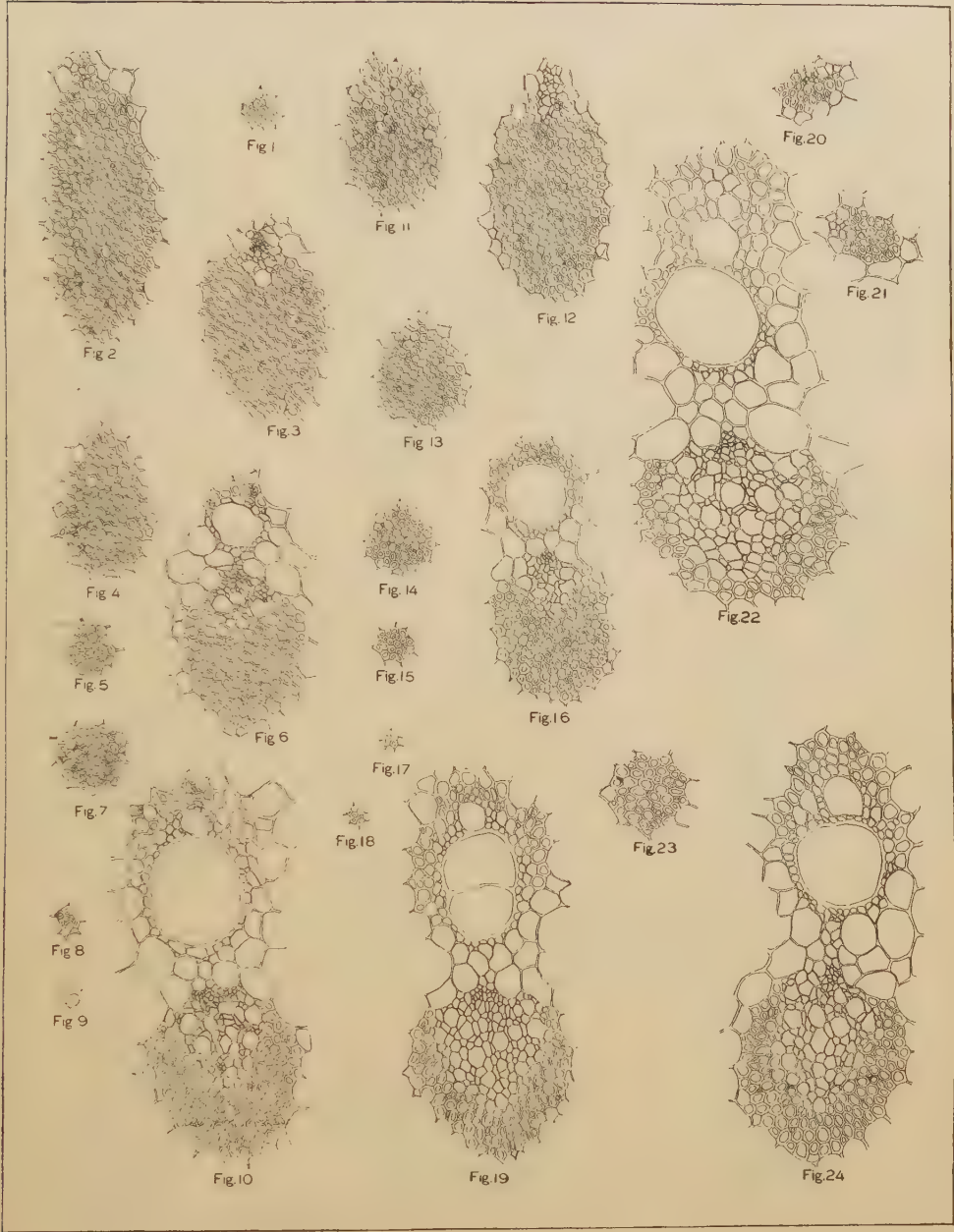


PLATE IV

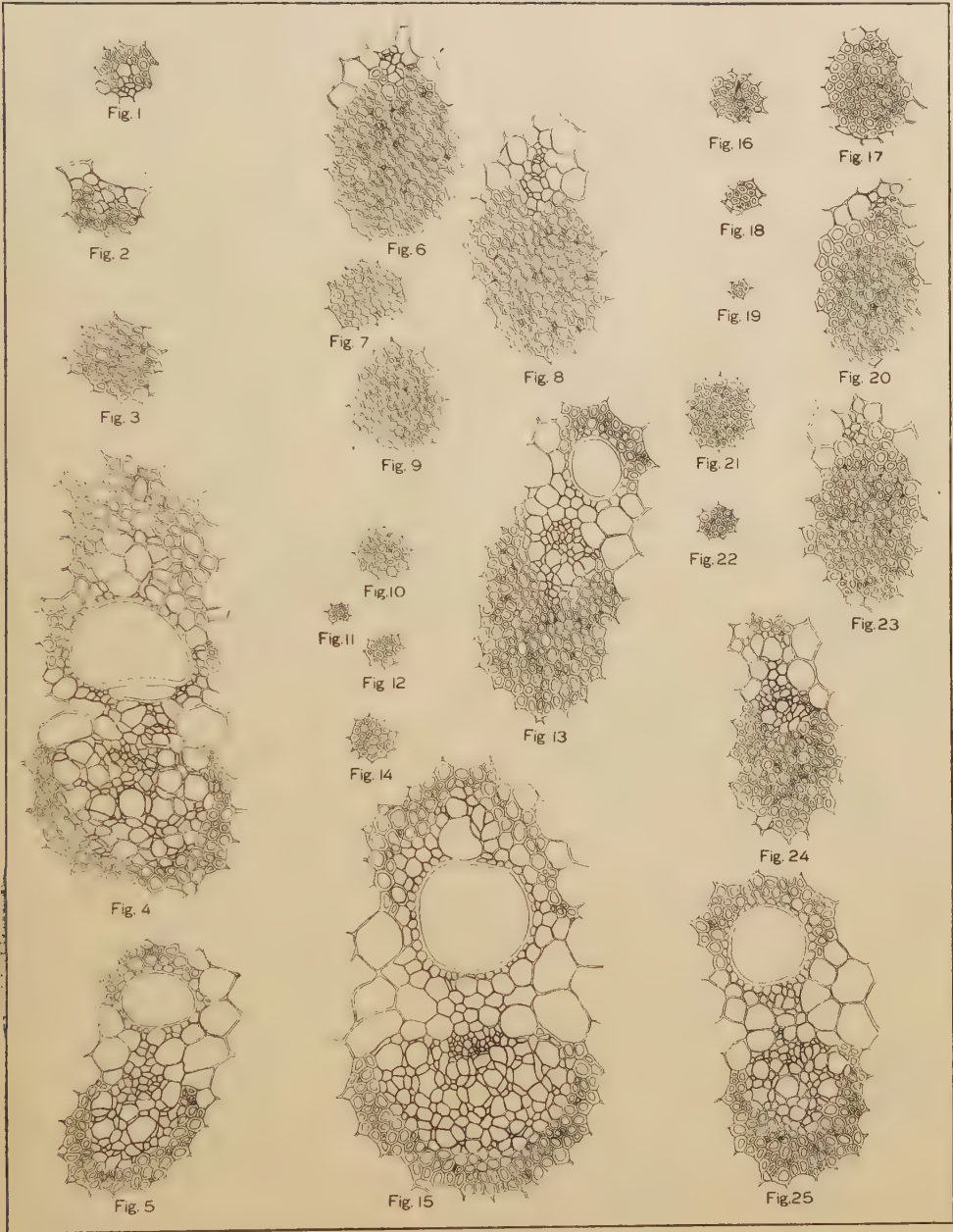


PLATE V

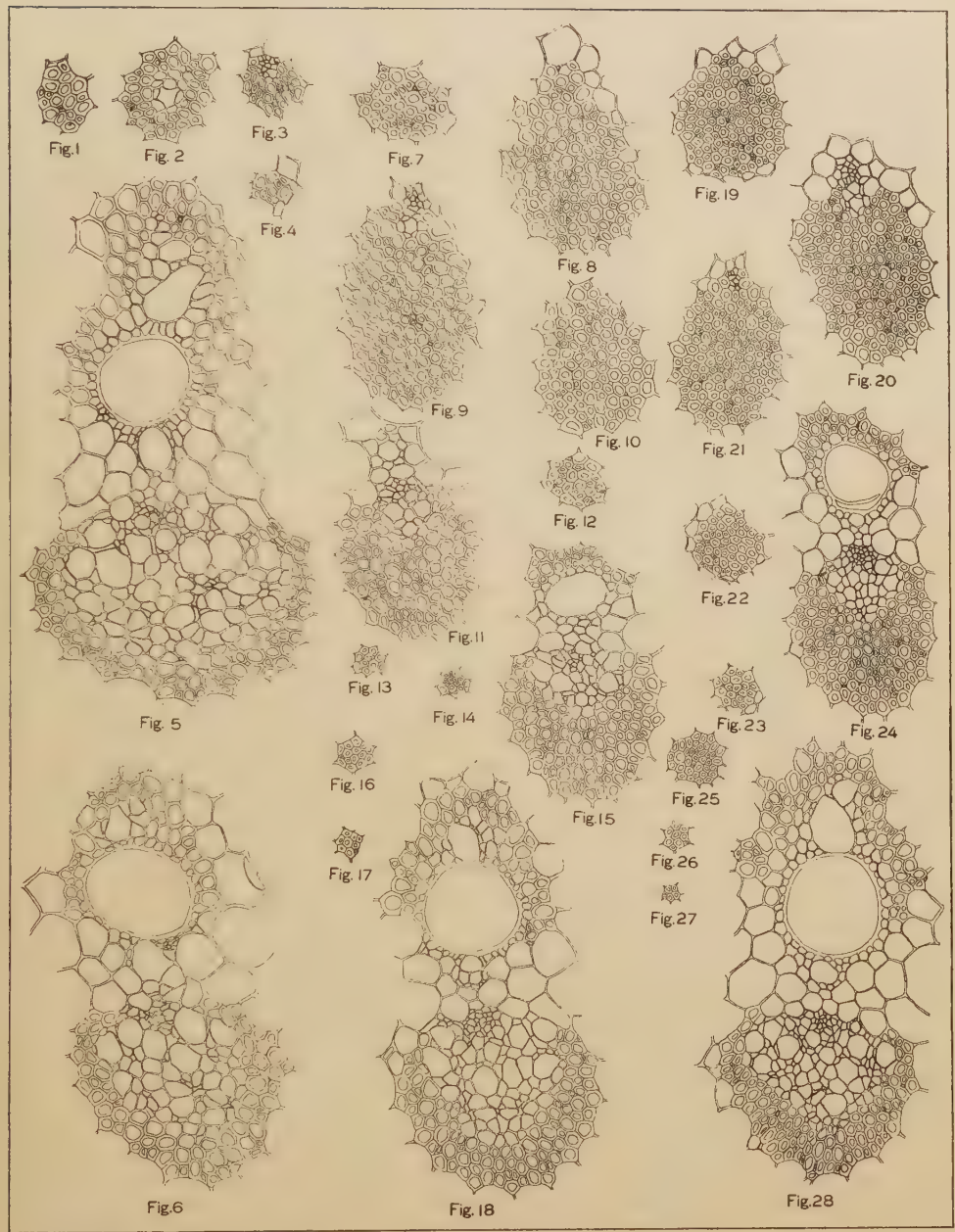


PLATE VI

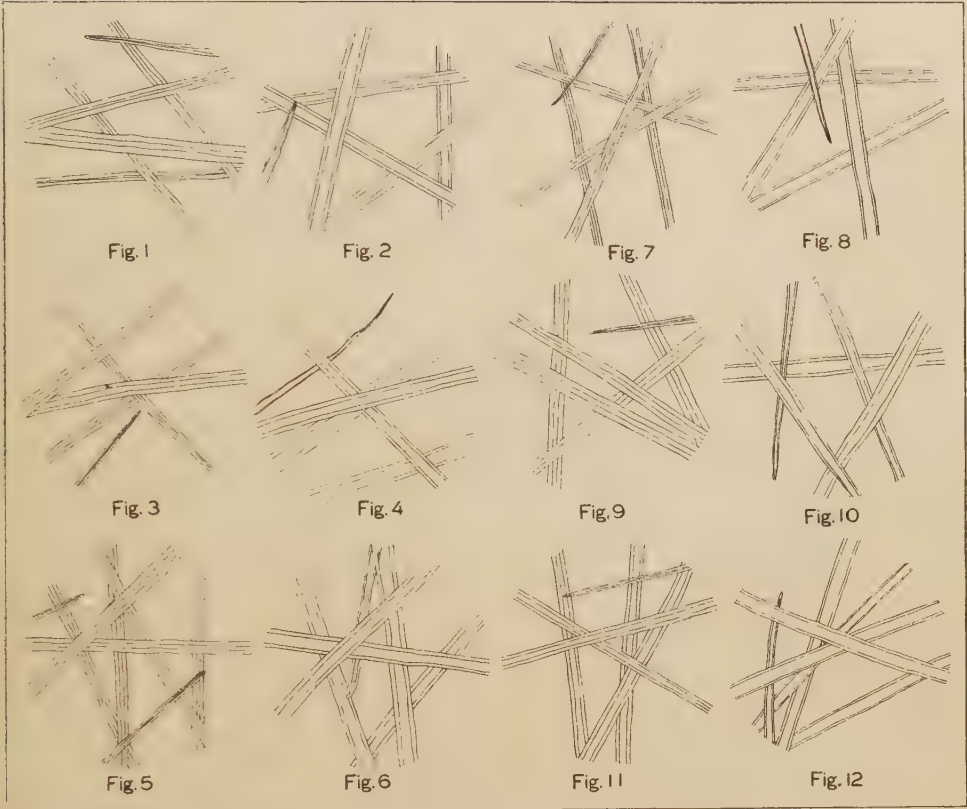


PLATE VII

COMPARISON OF FORTY-SEVEN VARIETIES OF ABACA GROWN UNDER LOS BAÑOS CONDITIONS¹

By R. B. ESPINO and TEOFILO NOVERO
Of the Department of Agronomy

This paper is a report of an attempt to study the root-systems of the varieties of abaca in this College that have attained full development. Incidentally, some of the gross vegetative structures were also studied. Some of the desirable as well as undesirable qualities are here reported. It is hoped that the facts here given may be of value from the cultural point of view and may contribute to our rather limited knowledge of the varieties as a whole.

MATERIALS, METHOD, AND RESULTS

The varieties of abaca here studied were gathered by the College from different parts of the Philippines. As our records show, each variety was given a College accession number and bears the name that it had in its place of origin.

The most thoroughly developed clump or hill of each of the varieties was studied. In case of individual plants only those that were flowering or fruiting were measured. In counting the plants of a clump, the small, as well as the large ones, were included.

In the study of the distribution of roots in the ground, a trench in the form of an arc one-half meter from the hill was dug vertically. The trench was about one-half meter in width and varied in length, depending upon the size of the clump of the plant. But its length was measured. The length of the remaining part of the circumference of a circle round the hill was also determined. The number of roots around each clump was calculated by dividing the number of roots in each trench by the length of the trench. The product was afterward multiplied by the sum of the lengths of the trench and of the circumference of a circle around the hill. The relative distribution in depth of the roots in each trench was determined by counting the roots in zones of five centimeters each from the surface of the ground. Owing to the large space that would be required to publish all the data, it was decided to show in this report only the results obtained from a few desirable varieties (See Table II).

Likewise, only a summary of the extensive data on hand is here included. Table I shows the comparison of the abaca varieties studied in certain vegetative structures.

DISCUSSION OF RESULTS

UNDESIRABLE QUALITIES

Examination of the data in Table I will show the following varieties possessing certain *undesirable* qualities:

a. *With less than 10 stalks to the hill.*—Banguisan, Baguisanon-Lawaan, Laguis (C. A.) 4285, Lagurhuan Dogami, Layahon, Libutanay, Linawaan, Pagonayan, Putian, and Sinibuyas.

¹ Experiment Station contribution No. 130.

b. With relatively short stalks.—Bolonganon, Inisarog, Laguis, Mininonga (C. A. 9274), Putianin.

c. With relatively small stalks.—Agutay, Bongulanon, Ihalas, Inusa, Kinalabao, Laguis (C. A. 10284), Lagurhuan-Dogami, Layahon, Luno, Mininonga, Moro, Pulahan, Putian, Sabaon, Samoro-puti, Sinibuyas, Sugmod, and Visaya.

d. With less than 140 roots round the hill.—Agogaron, Agutay, Bolonganon, Ihalas, Itehin-balud (C. A. 4273), Kinalabao, Laguis, Lagurhuan-Dogami, Maguindanao, Moro, Putian, Putianin, Sabaon, Makiling, Sinamoro, Sinanta-Cruz, and Sinibuyas.

DESIRABLE QUALITIES

Besides the *undesirable* qualities some of the varieties also possess qualities that may be considered as desirable. The following are from Table I:

a. With large and tall stalks.—Baguisanon-Lawaan, Libuton, Linawaan, and Maguindanao.

b. With more than 20 leaf-sheaths on each stalk.—Baguisanon-Lawaan, Bulao, Ilayas, Libuton, Sabaon, and Makiling (C. A. 10178).

c. With more than 150 roots on each mature plant.—Alman, Baguisanon-Lawaan, Lagurhuan-Burawen, Libuton, Linawaan, and Pagoonayan.

d. With roots as deep as one meter or more below the surface of the ground.—Alman, Baguisanon-basag, Bongulanon (C. A. 10291), Kinalabao, Lagurhuan-Burawen (C. A. 4275), Libuton, Mininonga (C. A. 10303), Pagoonayan, Pulahan, Putian, Sabaon, and Sinibuyas.

e. With more than 300 roots round the hill.—Baguisanon-basag, Kalado, Lagurhuan, Lagurhuan-Burawen, Pulahan, and Visaya.

FURTHER STUDY OF "DESIRABLE" AND "UNDESIRABLE" QUALITIES

It is interesting to note in Table I that although the criteria considered are few yet none of the varieties studied possess all the "desirable" qualities. Neither was a single variety found possessing all the "undesirable" varieties. Of the nine undesirable points only five were present in each of the very few varieties. The highest number of desirable points found in a variety was six or only 60 per cent perfect. From these data it is obvious that there is an extensive field for improvement of varieties. Such an improvement might be accomplished through selection, hybridization, and by an unexpected appearance of mutants, or sports. Following are some of the striking results given in Table I.

a. Possessing 4 or 5 of the undesirable qualities.—Agutay, Ihalas, Lagurhuan-Dogami, Moro, Putian, and Sinibuyas.

b. Possessing none of the desirable qualities for Los Baños conditions.—Agutay, Banguisan, Bolonganon, Ihalas, Inisarog, Inusa, Laguis, Lagurhuan-Dogami, Layahon, Libutanay, Luno, Mininonga, and Moro.

Comparing the two preceding lists of varieties we find that there are some varieties that possess the maximum four or five undesirable qualities at the same time possessing none of the desirable ones. They are Agutay, Ihalas, Lagurhuan-Dogami, and Moro. These may be considered truly undesirable, especially if we bear in mind that the varieties further possess the following points:

1. Agutay, with small stalks.
2. Ihalas, with small stalks and scanty root-system.

3. Lagurhuan-Dogami, a poor stooler, with small stalks and scanty root-system.

4. Moro, with small stalks and scanty root-system.

Table I shows also the following interesting data:

a. *Possessing four, five or six desirable qualities.*—Baguisanon-Basag, Baguisanon-Lawaan, Bulao, Itom, Lagurhuan, Libuton, and Sabaon.

b. *Possessing none of the undesirable qualities.*—Alman, Bulao, Kalado, Lagurhuan-Burawen, Libuton, Pongay.

The varieties Bulao and Libuton both possess the maximum number of desirable qualities and have none of the undesirable points. According to the criteria here employed these two varieties are exceptionally good. With the exception of Sabaon, the rest of the varieties included in the two immediately preceding lists are also good. The variety Sabaon has some undesirable qualities, namely, it produces small stalks and a scanty root-system, (See Table I). But Bulao was found by Reyes (1) to possess fiber with extremely low tensile strength and Libuton to produce fiber "not quite so white nor easy to strip" (2). It is obvious, then, that a variety may possess several of the desirable vegetative characters, hence it may appear to be suitable for extensive planting yet may yield fiber with certain undesirable qualities.

ROOT DISTRIBUTION

Like the rest of the vegetative structures of any plant the development of the root is greatly influenced by its environment. The type of soil, presence of rocks in it, and its moisture content are among the modifying factors. Roots growing in a clay soil may be expected to attain less perfect development than similar roots in a loam soil. Rocks may retard and distort the course of the growth of the roots. Both fertile and loose soil especially of volcanic origin are known to promote a full development of the root-systems of abaca while a soil comparatively poor in organic as well as inorganic substances is acknowledged to be capable of retarding development of the structure. However, in the present study the varieties were grown side by side on a piece of land scarcely one fourth of a hectare in area. The soil is deep and sandy loam in character. While the trenches were being dug it was found that the soil was fairly uniform in texture and free from anything that might hinder the development of the roots. It is then safe to assume that any difference in the distribution of the roots of the varieties studied was due mainly to natural varietal differences.

The number of roots found in successive horizontal layers five centimeters thick, beginning at the surface, varied according to varieties. Some varieties, Baguisanon-Lawaan and Libuton for instance, produced roots in the soil as deep as one meter from the surface. The Lagurhuan variety had more roots than any other variety shown in Table II. But its roots were not found below 85 centimeters. The Sabaon had a very scanty root-system. As shown in Table II abaca, like coconut (3) is somewhat of a surface feeder. A number of the roots from a hill was found within the first seven zones, or 35 centimeters below the surface of the ground. Most of the roots were found between the zones three and five. Because of this location of the roots care should be taken in the first cultivation of a plantation; for a deep cultivation may result in wholesale destruction of the roots of the plant.

The great practical value of detailed comparisons of this kind for the varieties in any given abaca district are apparent. It is of the highest possible importance to extend this more exact work to all abaca regions in connection with exhaustive studies of the character of the fibers of all the varieties, that are now being carried on.

SUMMARY OF CONCLUSIONS, FOR LOS BAÑOS CONDITIONS ONLY

(1) None of the varieties studied possess all the desirable qualities. Neither was a single variety found possessing all of the undesirable points.

(2) The varieties Agutay, Ihalas, Lagurhuan-Dogami, Putian, Moro, and Sinibuyas had the maximum four or five undesirable qualities. The yield of fiber and its qualities were not here considered.

(3) The varieties Baguisanon-Basag, Baguisanon-Lawaan, Bulao, Itom, Lagurhuan, Libuton, and Sabaon were found to possess the maximum number of desirable qualities. With the exception of Sabaon, which had some undesirable points, all of these varieties had none or practically none of the undesirable criteria employed.

(4) The varieties Bulao and Libuton, both possessing the maximum number of good points and at the same time having none of the bad points, might be considered good varieties. But the Bulao produces weak fiber and Libuton yields fiber "not quite so white nor easy to strip".

(5) Different varieties had different root-systems. Baguisanon-basag, Kalado, Lagurhuan, Lagurhuan-Burawen, Pulahan, and Visaya had more than 300 roots round the hill. If they possess other good qualities these varieties should be recommended for planting in places frequently visited by typhoon and drought.

(6) The varieties Agogaron, Agutay, Bolonganon, Ihalas, Itehin-balud, Kinalabao, Laguis, Lagurhuan-Dogami, Maguindanao, Moro, Putian, Sabaon, Makiling, Sinamoro, Sinanta-Cruz, and Sinibuyas had rather limited root-systems.

(7) Abaca is a surface feeder. Most of its roots may be found between 15 and 25 centimeters below the surface of the ground. Deep cultivation may injure most of the roots.

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TABLE I.—Comparison of abaca varieties in certain vegetative structures.

			Undesirable qualities.								Desirable qualities.										
	Variety name.	C. A. No.	Stalk.	Stool.				Plant.		Total number of points.	Stalk.				Stool.	Roots.		Total number of points.			
			Less than 1 meter in height.	Less than 15 cm. diam. at base.	Less than 10 plants to the hill.	More than 30 plants to the hill.	Less than 200 cm. circ. at base.	Without roots below 50 cm.	Less than 140 roots around stool.		Less than 6 leaves each.	Less than 100 roots each.	8 or more leaves.	Most number to the hill.	20 cm. diam. at base.	More than 3 meters high.	More than 20 leaf sheaths.		Circ. more than 300 cm. at base.	Circ. more than 500 cm. at top.	More than 150 to each plant.
1	Agoraron.....	9533							×	×	2	+					+				
2	Agutay.....	4272		×				×		×	4										
3	Alman.....	10304										+						+	+		3
4	Alman nga itom....	9272								×	1	+					+				2
5	Banguisan.....	9271			+						1										
6	Baguisanon-Basug...	4270							×	×	2				+		+		+	+	4
7	Baguisanon-Lawaan..	10308			×						1	+		+	+	+		+			5
8	Boñgulanon.....	4284		×		×				×	3		+		+						2
9	Boñgulanon.....	10291		×					×	×	3		+				+		+		3
10	Boloñganon.....	11163	×				×	×			3										
11	Bulao.....	10298										+		+		+					4
12	Ihalas.....	9273		×				×	×		4				+						
13	Ilayas.....	10287								×	1	+			+		+				3
14	Inisarog.....	9524	×								1										
15	Inusa.....	4294		×						×	2										
16	Inusa.....	10305		×					×	×	3										
17	Itehin Balud.....	4273						×			1					+	+				2
18	Itehin Balud.....	10289						×		×	2					+	+				2
19	Itom.....	4293				×					1	+		+		+	+				4
20	Itom.....	9529								×	1						+				1
21	Itom.....	10302				×				×	2	+				+	+				3
22	Kalado.....	4292										+				+	+		+		3
23	Kinalabao.....	11212		×				×		×	3								+		1
24	Kinosol.....	10307								×	1						+				1
25	Laguis.....	4285	×		×			×			3										
26	Laguis.....	10284		×				×			2										
27	Lagurhuan.....	9280								×	1	+			+		+			+	4
28	Lagurhuan Burawen.	4275														+		+	+	+	3
29	Lagurhuan Burawen.	10300												+				+			2
30	Lagurhuan Dogami..	10295		×	×		×	×		×	5				+						
31	Layahon.....	1030		×	×		×				3										
32	Libutanay.....	1033			×				×	×	3										
33	Libuton.....	100												+	+	+		+	+	+	6
34	Linawaan.....	4288			×				×	×	3			+	+			+			3
35	Luno.....	10283		×					×		2										
36	Maguindanao.....	4283						×	×		2	+	+	+							3
37	Makiling.....	10178						×		×	2				+						1
38	Mininoña.....	9274	×								1										
39	Mininoña.....	10303		×						×	2								+		1
40	Moro.....	10297		×			×	×		×	4										
41	Pagoonayan.....	1035			×						1							+	+		2
42	Pinoonan.....	1029														+	+				2
43	Pongay.....	9278															+				1
44	Pulahan.....	4296		×					×	×	3	+							+	+	3
45	Punucan.....	10296										+									1
46	Putian.....	11247		×	×			×		×	4				+				+		2
47	Putianin.....	9152	×					×			2						+				1
48	Sabaon.....	9532		×				×		×	3	+	+		+		+	+			5
49	Sinaba.....	10310							×		1						+				1
50	Sinamoro.....	9277					×	×		×	3				+						1
51	Samoro-Puti.....	4279		×					×	×	3		+								1
52	Sinantacruz.....	9531					×	×		×	3		+				+				2
53	Sinibuyas.....	11213		×	×			×		×	4								+		1
54	Sugmod.....	4282		×					×		2		+				+	+			3
55	Sugmod.....	10293							×		1						+	+			2
56	Visaya.....	4286		×							1					+				+	2
57	Visaya.....	10286							×		1			+						+	2

TABLE II.—Number of roots (computed) per zone of 5 centimeters from the surface of the ground.
The data are for the entire circle around the clump of abaca.

Variety \ Zones	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Alman	5	11	24	11	19	5	24	5	3	8	5	5	0	0	3					
Baguisanon- Lawaan	8	11	15	23	11	8	8	8	11	4	4	4	4	8	4	0	4	4	8	
Bulao	8	8	38	25	38	21	21	17	21	4	8	4	4	4	0	8				
Itom (C.A. 4293)	12	16	19	25	19	12	9	6	3	3	9	6	9	9	3	3				
Lagurhuan	0	33	40	33	30	26	13	20	17	10	10	3	3	7	10	3	3			
Libuton	6	9	15	9	15	6	12	3	12	18	6	6	9	12	0	6	0	3	6	3
Sabaon	4	0	0	0	2	2	2	7	11	14	2	0	0	0	2	0				



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